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<b>(21) International Application Number:</b> PCT/US96/15222 <b>(22) International Filing Date:</b> 23 September 1996 (23.09.96) <b>(30) Priority Data:</b> 60/009,455 29 December 1995 (29.12.95) US 08/610,424 4 March 1996 (04.03.96) US <b>(60) Parent Application or Grant</b> <b>(63) Related by Continuation</b> US Not furnished (CIP) Filed on Not furnished <b>(71) Applicant (for all designated States except US):</b> UNIVERSITY OF ARKANSAS [US/US]; Suite 601, 1123 South University, Little Rock, AR 72204 (US). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> BURKS, A., Wesley, Jr. [US/US]; 2400 North Pierce, Little Rock, AR 72207 (US). HELM, Ricki, M. [US/US]; 3207 Echo Valley Drive, Little Rock, AR 72207 (US). COCKRELL, Gael [US/US]; 31 Jay Circle, Cabot, AR 72023 (US). STANLEY, J., Steven [US/US]; 12714 Pleasant Forest, Little Rock, AR 72212			<b>(US). BANNON, Gary, A. [US/US];</b> 714 St. Michael Place, Little Rock, AR 72211 (US). <b>(74) Agent:</b> ALEXANDER, Daniel, R.; Head, Johnson & Kachigian, 228 West 17th Place, Tulsa, OK 74119 (US). <b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> With international search report.	
<b>(54) Title:</b> PEANUT ALLERGENS AND METHODS				
<b>(57) Abstract</b>  Crude Florunner extracts were fractionated by anion-exchange chromatography using a step gradient. A protein peak which eluted at 10 % NaCl and demonstrated intense IgE-binding was further analyzed by two-dimensional SDS- PAGE/immunoblot analysis. The majority of this fraction is a protein which has a molecular weight of 17 kD and a pI of 5.2. Sequencing data from the N-terminus revealed the following initial 9 amino acids: (*)-Q-Q-(*)-E-L-Q-D-L. Based on IgE-binding activity and no known amino acid sequence identity to other allergens, this allergen is designated Ara h II. Ara h II may be used to detect and quantify peanut allergens in foodstuffs. Serum IgE from patients with documented peanut hypersensitivity reactions and a peanut cDNA expression library were used to identify clones that encode peanut allergens. One of the major peanut allergens, Ara h I, was selected from these clones using Ara h I specific oligo-nucleotides and polymerase chain reaction technology.				

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**PEANUT ALLERGENS AND METHODS****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is a continuation-in-part of copending application Serial No. 08/610,424, filed March 4, 1996 and provisional application Serial No. 60/009,455, filed December 5 29, 1995.

**BACKGROUND OF THE INVENTION**

The present invention is directed to methods and apparatus for detecting and quantifying allergens in foodstuffs, and, more particularly, concerns peanut allergens, antigens, 10 monoclonal antibodies having specificity for peanut allergens, hybridoma cell lines which produce the monoclonal antibodies and immunoassay methods and apparatus including the monoclonal antibodies for detecting and quantifying peanut allergens in food-processing equipment and materials as well as natural, 15 processed, and finished foods.

The ingestion of peanuts is a common cause of food hypersensitivity reactions. Symptoms can vary from mild abdominal discomfort to severe anaphylaxis. In a recent report by Yunginger et al., "Fatal Food-Induced Anaphylaxis", Journal 20 of the American Medical Association 1988; 260:1450-2, four of seven patients who experienced fatal anaphylaxis died after peanut ingestion. All four of these patients unknowingly had eaten peanut in food prepared and consumed away from home. In the most recent studies involving children and food challenges, 25 peanut is among the three leading foods that cause food hypersensitivity reactions.

The increasing use of peanut products in our food supply has served to aggravate the problem of peanut allergy. Peanuts, generally in the form of peanut butter, are introduced into the American diet at a very young age. Some children  
5 react on challenge to peanut on their first known exposure, indicating that they had been sensitized in utero, by breast feeding, or by an unknown exposure. Unlike other food sensitivities in children, long-term follow-up studies of up to fourteen years indicate that peanut hypersensitivity is rarely  
10 outgrown.

It is important for peanut-sensitive individuals to have a means of recognizing and avoiding peanut-containing products. Unfortunately, peanut allergens have been identified in non-peanut foodstuffs manufactured on common processing equipment  
15 that were inadequately cleaned. Peanut products that serve as substitutes for other nuts in candies are not uncommon. In patients suffering from extrinsic asthma, hayfever, or atopic eczema, symptoms develop immediately after exposure to specific allergens. This immediate type of allergy is a function of a  
20 special type of serum antibodies called reagins. These reagins have been identified as belonging to the IgE class of immunoglobulins. Radioimmunoassays (RIA) have been developed to measure the level of circulating allergen specific IgE in human blood samples.

25 For example, Pharmacia Diagnostics AB, Uppsala, Sweden, manufactures a Phadebas RAST<sup>R</sup> radioimmunoassay (U.S. Patent Nos. 3,645,852 and 3,720,760). The Phadebas Rast<sup>R</sup> radioimmunoassay is an in vitro test system based on the Radio Allegro Sorbent Test principle for determination of circulating



specific IgE antibodies. The allergen of interest is covalently coupled to a solid phase. The allergen is reacted with a patient serum sample containing both allergen specific and non-specific IgE. The allergen reacts with the specific  
5 IgE in the patient sample. After washing away non-specific IgE, radioactively labeled antibodies against IgE are added forming a complex. Then unbound radioactively labeled anti-IgE is washed away. Next, the radioactivity of the bound complex is measured in a gamma counter. The more bound radioactivity  
10 found, the more specific IgE present in the sample. To classify the test results, patient counts are compared directly with counts of reference sera run in parallel. This system is designed for use in testing allergens including grass, tree, weed pollens, house dust, mites, foods, insects, epidermals,  
15 molds, drugs, occupational allergens, and parasites.

Pharmacia Diagnostics AB, Uppsala, Sweden also manufactures a Pharmacia IgE RIA Ultra solid-phase, sandwich radioimmunoassay for quantitative determination of total IgE in human serum. The serum concentration of IgE is significantly  
20 elevated in most patients with allergic diseases, such as extrinsic asthma, hayfever, and atopic disease. In this system, a monoclonal anti-IgE is covalently coupled to a test tube wall. This monoclonal reacts with the IgE in the samples during a first incubation. The tubes are then washed and  
25 radioactively labeled anti-IgE reacts with the bound IgE during a second incubation. After the second incubation, unbound radioactively labeled anti-IgE is washed away. The radioactivity in the tube is then measured and is directly proportional to the concentration of the IgE in the sample.

The use of a radioimmunoassay to detect peanut allergens in food processing materials and finished foods is described in a Keating et al. article entitled "Immunoassay of Peanut Allergens in Food Processing Materials and Finished Foods", appearing in the Journal of Allergy Clinical Immunology 1990; 86:41-4. To quantitate trace amounts of peanut allergens in food processing materials and finished foods, there was established a solid-phase radioimmunoassay inhibition using pooled sera from five peanut-sensitive subjects and roasted peanut meal extract covalently linked to polyacrylamide beads. Test samples were extracted, dialyzed, lyophilized, and reconstituted at 10 to 125 mg of dry weight per ml concentrations. The peanut allergen content of test samples was expressed relative to a reference extract of roasted peanut meal that was assigned an arbitrary potency of 100,000 U/ml. In confectionary products spiked with varying quantities of peanut, the recovery of peanut allergen ranged from 31% to 94%. The sensitivity of the assay was 2.5 U/mg of dry weight from the samples. Peanut allergens were undetectable in virgin vegetable oil used to roast peanuts, but 600 to 760 U/mg of dry weight were present in oil after varying periods of use. The allergen content of used oil was reduced to 8 U/mg of dry weight by filtration and steam cleaning. The availability of such a radioimmunoassay provides a way of monitoring finished food products for potential allergens.

In light of the foregoing, there is a need for an improved immunoassay for detecting and quantifying specific peanut allergens in food processing materials, equipment, and raw, processed, and finished foods.

## SUMMARY OF THE INVENTION

In accordance with the present invention, specific peanut allergens are identified and a monoclonal antibody based assay is provided for detecting and quantifying the specific peanut allergens.

The identification of a major peanut allergen, Ara h I, is described in an article "Identification of a Major Peanut Allergen In Patients With Atopic Dermatitis and Positive Peanut Challenges" by Burks et al., The Journal of Clinical Immunology, August 1991; Vol. 88, No. 2, pp 172-179. Serum from nine patients with atopic dermatitis in a positive double-blind, placebo-controlled food challenge to peanut was used to begin the process of identification and purification of the major peanut allergens. Identification of a major peanut allergen was accomplished by use of anion-exchange column chromatography, sodium dodecyl sulphate-polyacrylamide gel electrophoresis, ELISA, thin layer isoelectric focusing, and IgE-specific immunoblotting. Anion-exchange chromatography revealed several fractions that bound IgE from the serum of the challenged positive patient pool. By measuring anti-peanut-specific IgE in the ELISA and IgE-specific immunoblotting, there was identified an allergenic component with two Coomassie brilliant blue staining bands by sodium dodecyl sulphate-polyacrylamide gel electrophoresis with a mean molecular weight of 63.5 kD. Examination of this fraction by the IgE anti-peanut ELISA with individual serum and by the ELISA-inhibition assay with pooled serum, lead to its identification as a major allergen. Thin layer isoelectric focusing and immunoblotting of the 63.5 kD fraction revealed it

to have an isoelectric point (pI) of 4.55. Based on allergen nomenclature of the IUIS subcommittee for allergen nomenclature, this allergen was designated Ara h I (Arachis hypogaea).

5        Burks et al. also identified and characterized a second major peanut allergen, Ara h II, as described in an article entitled "Identification and Characterization of A Second Major Peanut Allergen, Ara h II, With Use of the Sera of Patients with Atopic Dermatitis in Positive Peanut Challenge", Journal  
10 of Allergy and Clinical Immunology, December 1992; Vol. 90. Again, serum from nine patients with atopic dermatitis in a positive double-blind, placebo controlled, food challenge to peanut was used in the process of identification and purification of the peanut allergen. Identification of a  
15 second major peanut allergen was accomplished with the use of various biochemical and molecular techniques. Anion exchange chromatography of the crude peanut extract produced several fractions that bound IgE from the serum of the patient pool with positive challenges. By measuring anti-peanut specific  
20 IgE and by IgE specific immunoblotting, there was identified an allergic component that has two closely migrating bands with a mean molecular weight of 17 kD. Two-dimensional gel electrophoresis of this fraction revealed it to have a mean isoelectric point of 5.2. According to allergen nomenclature  
25 of the IUIS subcommittee for allergen nomenclature, this allergen is designated, Ara h II (Arachis hypogaea).

The Ara h I allergen bound IgE in over 90% of a group of six patients with peanut hypersensitivity as shown in Table 1. Multiple monoclonal antibodies were made to this peanut

allergen as shown in Table 2. Two of these monoclonal antibodies recognizing distinct epitopes were chosen to prepare a two-site immunometric ELISA for quantitating the 63.5 kD peanut allergen in food products. One was chosen as the capture monoclonal antibody and the other was biotinylated and used as the detection monoclonal antibody in an avidin-biotin assay.

In accordance with one embodiment of the present invention, defatted roasted Florunner peanuts were used as the peanut standard. A microtiter plate was coated with 1  $\mu$ g/ml of the capture monoclonal antibody 8F10. After incubation for one hour, the plate was washed three times and either the peanut standard or an unknown sample was added. The Florunner standard extract ranged from 0.01 ng/ml to 10 ng/ml total protein. Following incubation at 25°C for one hour, the plates were washed and then the biotinylated second antibody 8D9 was added at a concentration of 1:500 v/v. The plates were again incubated at 25°C for one hour and developed by the addition of a horseradish peroxidase-avidin (HRP-avidin) conjugate, followed by citric acid substrate and stopped by the addition of 2N hydrochloric acid. The microtiter plates were read at 495 nm on a Titertek Multiscan. The results were plotted on a log-logit paper to obtain 63.5 kD allergen concentration from the standard curve (see Fig. 1). The assay had an inter-assay coefficient of variation of less than 6%. In each sample run, the linear correlation coefficient was greater than or equal to 0.98.

As shown in Table 3, test samples included commercially purchased candies and oils. Candies that included peanut on

the label and other candies that did not have peanut as a listed ingredient were tested. Also, oils made from either peanut or vegetable oils were tested. Samples were prepared by weighing out 2.5 gms of each candy and then extracting each in 5 50 ml of 1 M NaCl, 20 mM NaH<sub>2</sub>PO<sub>4</sub> and 8 M urea with constant agitation overnight at 4°C. Particulate material was removed by filtration through 4X4 rayon polyester gauze (Johnson & Johnson). The sample was then centrifuged at 18,000 rpm for one hour and the supernatant collected. After dialysis, all 10 fractions were lyophilized and stored at 4°C until used in the assay.

Table 4 shows the results of the monoclonal antibody ELISA with the different candy products. The first column shows the results of the candies with peanut listed on the label. The 15 results range from Peanut Butter M&M's<sup>®</sup> with 299 ng/ml of allergen to plain M&M's<sup>®</sup> with 7.35 ng/ml of allergen. The second column shows the results of the five candies tested with no peanut listed on the label. No peanut allergen could be detected in any of these candies.

20 Table 5 shows the results of the monoclonal antibody ELISA for the various oils tested. No Ara h I could be detected in any of the oils tested from peanut, vegetable, canola, or soybean oil. No oil was tested that had previously been used for roasting peanuts. The lower limits of detection of added 25 peanut to a candy product in this assay appears to be approximately 1% peanut.

The ELISA assay of the present invention differs from the radioimmunoassay (RIA) developed by Yunginger et al. in several ways. The Yunginger RIA is an RIA-inhibition assay with pooled

human IgE serum from peanut-sensitive patients as the detection antibody. In the RIA-inhibition assay the serum IgE pool from peanut positive individuals would contain IgE antibody against more allergens than just Ara h I. In contrast, the present  
5 ELISA assay can be used to determine the concentration of a specific peanut allergen (Ara h I) in extracted peanut products.

With the use of the present monoclonal antibody ELISA, questions regarding threshold exposure levels in highly  
10 allergic patients can be answered and can provide a way to correlate quantities of ingested allergens with the development of clinical symptoms. Contamination of products with other food proteins occurs more frequently than probably appreciated. The ability to monitor food products with the potential to be  
15 contaminated is important. The present assay provides a new level of sophistication in the study of peanut hypersensitivity.

The principle object of the present invention is the provision of a monoclonal antibody enzyme-linked immunosorbent  
20 assay for peanut allergen. Another object of the present invention is the isolation and purification of peanut allergens. A still further object of the present invention is the provision of peanut allergen antigens and monoclonal antibodies having specificity for a selected peanut allergen  
25 antigen. Yet another object of the present invention is the provision of hybridomas which produce monoclonal antibodies specific for peanut allergen.

Still yet another object of the present invention is the provision of a two-site monoclonal antibody based enzyme-linked

immunosorbent assay that can be used to detect and determine the concentration of a specific peanut allergen such as Ara h I in a food product or food processing and producing equipment or materials.

5        Another object of the present invention is the provision of a process for producing monoclonal antibodies specific to a selected peanut allergen, hybridoma cell lines which produce such monoclonal antibodies, and an immunoassay which utilizes the monoclonal antibodies for detecting the presence and  
10 concentration of a selected peanut allergen. And, still yet another object of the present invention is the provision of a monoclonal antibody based enzyme-linked immunosorbent assay which does not contain human blood derivatives or radioactively labeled antibodies.

15        Other objects and further scope of the applicability of the present invention will become apparent from the detailed description to follow taken in conjunction with the accompanying drawings wherein like parts are designated by like reference numerals.



## BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a graphical representation of absorbance relative to allergen concentration;

FIGURE 2 is an illustration of the anion-exchange  
5 chromatogram of the crude peanut extract;

FIGURE 3 is a bar graph representation of the amount of anti-peanut IgE related to the crude peanut extract and each of the pooled fractions;

FIGURE 4 is a graphical illustration of inhibition  
10 relative to concentration of crude peanut extract and fraction 3;

FIGURES 5 - 9 are schematic illustrations of a two-site monoclonal antibody enzyme-linked immunosorbent assay in accordance with one embodiment of the present invention;

FIGURE 10 is a graphical representation of absorbance  
15 relative to time;

FIGURE 11 is an illustration of SDS-PAGE and immunoblotting of the defatted crude peanut extract;

FIGURE 12 is a bar graph representation of the amount of  
20 anti-peanut IgE related to defatted crude peanut extract and pooled fractions;

FIGURE 13 is a graphical illustration of inhibition relative to concentration of crude peanut extract and anion-exchange fraction 4; and

FIGURE 14 is a representation of blue stain of 2-  
25 dimensional gel with fraction 4 containing the 17kD allergen.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with a preferred embodiment of the present invention, a monoclonal antibody (MAb) based enzyme-linked immunosorbent assay (ELISA) and method is provided for  
5 detecting and quantifying a major peanut allergen, Ara h I, in food products. The Ara h I peanut allergen (63.5 kD fraction) was used as an immunogen to produce monoclonal antibodies (MAbs) having specificity for the selected peanut allergen. The Ara h I allergen was isolated as described in the Burks et  
10 al. article entitled "Identification of a Major Peanut Allergen, Ara h I, In Patients With Atopic Dermatitis and Positive Peanut Challenges", Journal of Allergy Clinical Immunology 1991; 88:172-9.

Patients with atopic dermatitis (AD) who had positive  
15 double-blind, placebo controlled, food challenge to peanut were used in the process of identification and purification of the peanut allergens. A major peanut allergen, Ara h I, was identified by use of anion-exchange column chromatography, sodium dodecyl sulphate polyacrylamide gel electrophoresis  
20 (SDS-PAGE), ELISA, thin layer isoelectric focusing (TLIEF) and IgE-specific immunoblotting. The Ara h I allergen is a glycoprotein from a pure strain of Florunner peanuts that has a mean molecular weight of 63.5 kD and a mean isoelectric point (pI) of 4.55.

25 Nine patients (mean age 4.2 years) with AD and a positive immediate prick skin test to peanut had either a positive DBPCFC or a convincing history of peanut anaphylaxis. (The allergic reaction was potentially life-threatening, that is, laryngeal edema, severe wheezing and/or hypotension.) Five

milliliters of venous blood was obtained from each patient and allowed to clot, and then the serum was collected. An equal volume of serum from each donor was mixed to prepare a nine-person, peanut-specific, IgE antibody (Ab) pool.

5        Three commercial lots of southeastern runners (*Arachis hypogaea*) (Florunner), medium grade peanuts from the 1979 crop (North Carolina State University), were used in this study. The peanuts were stored in the freezer at  $-18^{\circ}\text{C}$  until they were roasted. The three lots were combined in equal proportions and  
10        blended before defatting. The defatting process (defatted with hexane after roasting for 13 to 16 minutes at  $163^{\circ}$  to  $177^{\circ}\text{C}$ ) was done in the laboratory of Dr. Clyde Young (North Carolina State University). The powdered crude peanut was extracted according to the recommendations of Yunginger (Yunginger JW,  
15        Jones RT. A review of peanut chemistry: implications for the standardization of peanut extracts. In Proceedings of the Fourth International Paul Ehrlich Seminar on the Regulatory Control and Standardization of Allergenic Extracts. Bethesda, Maryland, Oct. 16-17, 1985, Stuttgart: Gustav Fischer Verlag,  
20        1987:251-64) in 1 mol/L of NaCl to 20 mmol/L of sodium phosphate (pH 7.0), with the addition of 8 mol/L of urea for 4 hours at  $4^{\circ}\text{C}$ . The extract was isolated by centrifugation at 20,000 g for 60 minutes at  $4^{\circ}\text{C}$ .

      Analytic and preparative anion-exchange chromatography was  
25        performed with the fast protein liquid chromatography (FPLC) system (Pharmacia, Piscataway, New Jersey). Anion-exchange chromatography was used with the Mono Q 5/5 and 10/10 columns (Pharmacia). The crude peanut extract was dialyzed against 20 mmol/L of Tris-bis-propane (pH 7.2) and 8 mol/L of urea, and 40

mg was loaded onto the Mono Q 10/10 column. A stepwise salt gradient of 0 to 1.5 mol/L of NaCl was applied. All fractions of each resolved peak were pooled, dialyzed, and lyophilized.

Dot blotting was done to determine which fractions from the anion-exchange column chromatogram contained IgE-binding material. The collected fractions (200 $\mu$ l) were blotted with the Mini Blot apparatus (Schleicher & Schuell Inc., Keene, New Hampshire) onto 0.45 micron nitrocellulose membranes (Bio-Rad Laboratories, Richmond, California). After membranes were dried, the remaining active sites were blocked with 20 ml of blocking solution (0.5% gelatin with 0.001% thimerosal in 500 ml of PBS) for 1 hour. The procedure is then identical to the immunoblotting for IgE described below.

The electrophoresis procedure was a modification of the method of Sutton et al. (Sutton R, Wrigley CW, Baldo BA. Detection of IgE and IgG binding proteins after electrophoresis transfer from polyacrylamide gels. Journal of Immunological Methods, 1982; 52:183-6.) SDS-PAGE was performed with a 12.5% polyacrylamide separating gel and a stacking gel of 3%. Twenty microliters of a 1 mg/ml solution of each protein was applied to each well. Replicate samples were applied for independent analysis. Electrophoresis was performed for 4 hours at 0.030 A per gel (E-C Apparatus Corp., St. Petersburg, Florida) for the 14 cm by 12 cm gels, and for 1 hour at 175 V per gel for the 8 cm by 7.5 cm gels (Mini-Protean II system, Bio-Rad Laboratories). To assure proper protein separation and visualization, Coomassie brilliant blue (Sigma Chemical Co., St. Louis, Missouri) stains were done on the gels. For detection of carbohydrate staining material, gels were stained

with the modified PAS stain according to the method of Kapitany (Kapitany R, Zebrowski EJ. A high resolution PAS stain for polyacrylamide gel electrophoresis.

Anal Biochem 1973; 56:361-9).

5 Proteins were electrophoretically transferred from the separating gel to a nitrocellulose membrane in a transfer buffer (Tris-glycine) with 10% SDS and 40% methanol. The procedure was done in a transblot apparatus (Bio-Rad Laboratories) for 2 hours (0.150 A) (regular size transfer  
10 apparatus for crude peanut and minitransfer apparatus for fraction 3). An amido black stain (Bio-Rad Laboratories) was done to assure transfer of the protein.

After removal from the transblot apparatus, the nitrocellulose was placed in blocking solution overnight at  
15 4°C. The nitrocellulose blot was then washed three times with PBS (PBS with 0.05% Tween 20) and incubated with the pooled serum (1:20 vol/vol dilution) for 2 hours at 4°C with rocking. After the nitrocellulose blot was again washed with PBS three times, alkaline phosphatase-conjugated goat antihuman IgE  
20 (1:1000 vol/vol of PBS, Bio-Rad Laboratories) was added and incubated at room temperature with rocking for 2 hours. After an additional wash with PBS three times, the blot was developed with 250 µl of 30 mg of nitro blue tetrazolium in 70% dimethylformamide and 250 µl of 15 mg of  
25 5-bromo-4-chloro-3-indolyl-phosphate in 70% dimethylformamide (Bio-Rad Laboratories) solutions in 25 ml of carbonate buffer (0.2 mol/L, pH 9.8) at room temperature for 15 minutes. The reaction was then stopped by decanting the 30 mg of nitro blue tetrazolium in 70% dimethylformamide/15 mg of 5-bromo-

4-chloro-3-indolyl-phosphate in 70% dimethylformamide solution and incubating the nitrocellulose for 10 minutes with distilled water. The blot was then air-dried.

A biotin-avidin ELISA was developed to quantify IgE  
5 antipeanut protein Abs with modifications from an assay previously published. The upper two rows of a 96-well microtiter plate (Gibco, Santa Clara, California) were coated with 100  $\mu$ l each of equal amounts (1  $\mu$ g/ml) of antihuman IgE MAbs, 7.12 and 4.15 (kindly provided by Dr. A. Saxon) in  
10 coating buffer (0.1 mol/L of sodium carbonate-bicarbonate buffer, pH 9.5). The remainder of the plate was coated with one of the peanut extracts at a concentration of 1  $\mu$ g/ml in coating buffer. The plate was incubated at 37°C for 1 hour and then was washed five times with rinse buffer (PBS, pH 7.4,  
15 containing 0.05% Tween 20; Sigma Chemical Co.) immediately and between subsequent incubations. In the upper two rows we used a secondary standard IgE reference to generate a curve for IgE, ranging from 0.05 to 25 ng/ml.

The serum pool and individual patient serum samples were  
20 diluted (1:20 vol/vol) and dispensed in duplicate in the lower portion of the plate. After incubation for 1 hour at 37°C and a subsequent washing, biotinylated, affinity-purified, goat antihuman IgE (KPL, Gaithersburg, Maryland) (1:1000 vol/vol of PBS) was added to all wells. Plates were incubated again for  
25 1 hour at 37°C and washed, and 100  $\mu$ l of horseradish peroxidase- avidin conjugate (Vector Laboratories, Burlingame, California) was added for 30 minutes. After plates were washed, they were developed by the addition of a buffer containing o-phenylenediamine (Sigma Chemical Co.). The

reaction was stopped by the addition of 100  $\mu$ l of 2-N-hydrochloric acid to each well, and absorbance was read at 492 nm (Titertek Multiscan, Flow Laboratories, McLean, Virginia). The standard curve was plotted on a log-logit scale  
5 by means of simple linear regression, and values for the pool and individual patient samples were read from the curve as "nanogram-equivalent units" per milliliter (nanogram per milliliter).

A competitive ELISA-inhibition analysis was done with the  
10 FPLC fractions. One hundred microliters of pooled serum (1:20 vol/vol) from the positive-challenge patients was incubated with various concentrations of the FPLC protein fractions (0.00005 to 50 ng/ml) for 18 hours at 4°C. The inhibited pooled serum was used in the ELISA described above. The  
15 percent inhibition was calculated by taking the food-specific IgE value divided by the food-specific IgE value. The number is multiplied by 100 to get the percentage of inhibition.

The samples were focused with the LKB Multiphor system with LKB PAG plates, pH gradient, 3.5 to 6.85 (LKB, Bromma,  
20 Sweden). Five microliters of sample (100  $\mu$ g of protein) was applied, and an electric current of 200 V was applied for 30 minutes. The gel was fixed and stained with Coomassie brilliant blue following the standard protocol (LKB). For IgE immunoblotting, the protein was transferred to nitrocellulose  
25 by capillary transfer and stained as described in the immunoblotting section above.

Pilot experiments were conducted with the analytical Mono Q 5/5 anion-exchange column to determine the optimal buffer system and salt gradient. Scale up and optimization was

completed with the Mono Q 10/10, with a stepwise salt gradient (0 to 1.5 mol/L of NaCl). The procedure separated the crude peanut extract into seven peaks (see Figure 2). Preliminary dot blotting from the separation identified IgE-binding material in each peak. Multiple runs of this fractionation procedure were performed, and each isolated peak was pooled, dialyzed against 100 mmol/L of  $\text{NH}_4\text{HCO}_3$ , and lyophilized. Preliminary separation of crude peanut extract with gel filtration (Superose) did not significantly enrich the purification process.

Initial SDS-PAGE and immunoblotting of the crude peanut extract revealed multiple protein fractions with several IgE-staining bands. Aliquots of the seven lyophilized fractions from the anion-exchange column were analyzed by SDS-PAGE. Immunoblotting for specific IgE with the pooled serum revealed two closely migrating bands that bound significant IgE. Preliminary blots with normal control serum and with serum from patients with elevated serum IgE values revealed no non-specific binding to this fraction. The two bands in fraction 3 stained positive for PAS. In addition, this fraction did not bind to Con A (after staining with biotinylated Con A and alkaline phosphatase-conjugated anti-biotin).

ELISA results comparing the crude peanut extract to each isolated fraction are illustrated in Figure 3. Mono Q 10/10 fractions 2a, 3, and 4 had significant amounts ( $>50$  ng/ml) of IgE binding compared to the crude peanut extract. We additionally tested the serum of six patients (members of the pooled serum) to determine the relative IgE binding to both the



crude and the enriched allergen fraction containing the 63.5 kD component (fraction 3). The results are presented in Table 6.

Each patient's serum had measurable amounts of peanut-specific IgE to both the crude extract and the 63.5 kD fraction. Serum  
5 from patients with AD, elevated serum IgE values, and positive DBPCFCs to milk (patient No. 7) and from healthy normal controls (patient No. 8) did not have detectable peanut-specific IgE to this allergen.

The ELISA-inhibition results are illustrated in FIG. 4.  
10 The concentration of the 63.5 kD fraction required to produce 50% inhibition was 5.5 ng/ml compared to 1.4 ng/ml of the crude peanut extract. Control experiments with other food proteins did not demonstrate significant inhibition, demonstrating the specificity of the inhibition assay.

15 Because immunoblotting and ELISAs of the various anion-exchange fractions demonstrated that fraction 3 contained a major allergen, isoelectric focusing (IEF) and immunoblotting were done on this fraction. Two bands were observed in this allergen that migrated closely together at 63.5 kD on SDS-PAGE,  
20 stained with Coomassie brilliant blue, and had a mean pI of 4.55. This protein fraction readily binds IgE from the pooled serum.

Monoclonal antibodies (MAbs) specific to the Ara h I peanut allergen were produced as follows. BALB/c mice were  
25 given 3 intraperitoneal injections of 25  $\mu$ g of the 63.5 kD fraction at 2- week intervals. Two weeks after the final injection the sera were screened for IgG antipeanut antibodies using a peanut- specific IgG ELISA. The positive mice were sacrificed and spleen cells from the sacrificed mice were fused

with 8-azaguanine resistant P3X63-Ag8.653 mouse myeloma cells using 50% polyethylene glycol.

Hybrids, which were selected on the basis of the IgG binding assay, were cloned by limiting dilution. Positive clones were selectively expanded and injected intraperitoneally into pristane-primed female BALB/c mice. The resulting ascites was purified by a Protein G column on the FPLC system (Pharmacia).

Four MABs identified as 8D9, 8F10, 2E9, and 7B3 were used in two-site immunometric assays to measure peanut and other legume antigens by solid phase ELISA. To determine the epitope specificity of each MAB, ELISA-inhibition studies were done with the biotinylated MAB. For detection of specific binding of the MABs to the 63.5 kD allergen, electrophoresis and immunoblotting were done.

Monoclonal antibody 8F10 was used to affinity purify the allergen identified. Monoclonal antibody 8F10 (approximately 300 mg of purified MAB) was coupled to 8 grams of CNBr-activated Sepharose 4B according to the manufacturer's instructions. Two hundred milliliters of crude peanut extract were absorbed over the column at a flow rate of 20 ml/hr. After adsorption, the column was washed with digestion buffer and the bound allergen eluted using 4mM HCL, pH 3.0. The collected fractions were screened for peanut-specific allergen by the previously described ELISA and assessed for purity by SDS-PAGE.

Four of the MABs (subtyped as lambda chain IgG1) were used for immunoblotting against the 63.5 kD allergen. In a two-site immunometric assay each MAB was used as the capture antibody

and the serum pool, either the peanut positive IgE serum pool or normal serum pool, was used as the second antibody. The results show that each MAb had significant amounts of binding to the crude peanut material, the 63.5 kD peanut allergen (Ara h I), and the 17 kD peanut allergen (Ara h II) but no significant binding to other legumes, including soy, peas, chick peas, green beans, and lima beans (Table 7). The assays using the normal serum pool showed no significant binding.

In the next ELISA the MAbs were again used as the capture antibody with individual serum used as the second antibody (Table 8). Some individual variation occurred among the individual patients, but each patient included in the peanut positive pool had significant amounts of binding while the patients with normal serum had less than 8.0%.

ELISA-inhibition studies were done with seven MAbs to determine the epitope specificity of each. Biotinylated MAb was incubated with differing concentrations of each of the other MAbs (including a MAb for Alt1, the primary allergen from Alternaria). The inhibition was graded from 0+ (none) to 4+ (significant) (Table 2). Monoclonal antibodies 8D9 and 8F10 had the least amount of cross-inhibition between the 4 MAbs.

The allergen purified by MAb 8F10 was isolated from Florunner peanut extract by MAb affinity chromatography. The eluted fraction has 2 major bands on SDS-PAGE at a mean MW of 63.5 kD. The radiolabeled IgE immunoblot with the pooled peanut positive serum showed significant IgE binding.

Since over 90% of six patients with documented food hypersensitivity reactions to peanut demonstrate specific-IgE to the Ara h I allergen (63.5 kD fraction), an ELISA assay

which would detect this allergen in food products was developed.

A total of thirty hybridoma subclones were identified for screening. The number of subclones was reduced to twenty by  
5 ELISA and SDS-PAGE/Western blotting to determine the binding affinity and specificity using whole peanut extracts. From the twenty subclones the following thirteen were frozen in liquid nitrogen for further testing: hybridoma cell lines 2H9, 2G10, 10B3, 2E9, 4HB, 10A3, 6B5, 7D9, 1B6, 7B3, 8F10, 6F9, and 8D9.

10 Seven cell lines producing high titer immunoglobulins (MAbs) and having a considerable amount of ascites fluid in mice providing for the recovery of a significant amount of immunoglobulin were selected for further testing (8F10, 8D9, 6B5, 7B3, 2E9, 6F9, and 1B6). The MAbs 8F10 and 8D9 were  
15 isolated from the hybridoma cell lines 8F10 and 8D9 supernatants and used as the standard two-site ELISA assay. Cell culture supernatants from the five remaining cell lines were tested to determine their specificity and binding inhibition in the assays. Small quantities of ascites were  
20 also tested by ELISA to determine capture and detection MAb pairings.

Based on the above testing, the preferred capture and detection (biotinylated) MAb pairs include 8F10 and 8D9, 7B3 and 1B6, 2E9 and 6B5, and 2E9 and 8D9. In these monoclonal  
25 antibody pairs, either antibody can be used as the capture or detection antibody in the two-site monoclonal antibody enzyme-linked immunosorbent assay of the present invention. For example, assays have been developed using the MAb 8F10 as the capture Ab and MAb 8D9 as the detection Ab or with MAb 8D9

as the capture Ab and MAb 8F10 as the detection (biotinylated) Ab. Other possible MAb pairings include MAbs 7B3 and 2E9, 7B3 and 6B5, 7B3 and 6F9, and 2E9 and 6F9. As shown in Table 2, each of the MAbs 8F10, 8D9, 2E9, 7B3, 1B6, 6B5, and 6F9 were  
5 tested as the capture and detection antibody in combination with each of the other antibodies.

Table 9 shows the results of site specificity testing for each of seven MAbs with respect to four binding sites (epitopes) on the Ara h I peanut allergen. The results  
10 relating to specificity for the four sites labeled A, B, C, and D are based on the use of capture and detection MAbs, while the results relating to the three sites labeled X, Y and Z are based on the use of MAbs in combination with peanut positive serum pool IgE antibody. It is not known whether the three  
15 sites A, B, and D are the same three sites X, Y and Z.

IgG1 products from hybridoma cell lines produced against Ara h I were used to develop a 2-site monoclonal antibody ELISA. In one example, monoclonal antibody 8D9 was used as the capture antibody, and monoclonal antibody 8F10 was biotinylated  
20 to use as the second antibody.

A crude Florunner peanut extract was used as the standard. Five food products with peanuts on the label (including plain M&M's<sup>®</sup>, which contain peanuts), five food products without peanuts on the labels, three commercial peanut oils and two  
25 commercial soybean oils were used as extract source material. The amount of Ara h I in the peanut-labeled products varied from 1.4 µg/ml to 1777 µg/ml. No Ara h I allergen could be detected in peanut oil, soybean oil or in any of the nonpeanut food extracts. The present ELISA for Ara h I is useful for

screening food products for this peanut allergen and for correlating the amount of peanut allergen which might cause significant clinical reactions.

With reference to Figs. 5 - 9 of the drawings and in accordance with an exemplary embodiment of the present invention, an ELISA for peanut allergen is produced and analyzed as follows. The 8F10 monoclonal antibody is diluted 1:1000 v/v in coating buffer; concentration is approximately 1-5  $\mu\text{g/ml}$  in 0.1 M sodium carbonate/sodium bicarbonate buffer, pH 9.2. One hundred microliters is added to each well of a 96-well microtiter plate and incubated overnight at 4°C (Fig. 5).

The coating buffer with monoclonal antibody 8F10 is thoroughly washed from the wells with phosphate buffer containing 0.05% Tween 20.

Dilutions of a known peanut extract (0.05 - 50  $\mu\text{g}$ ) and the 63.5 kD allergen are prepared to establish a standard curve. Dilutions of the unknown are prepared to determine if they contain the 63.5 kD allergen. One hundred microliters of the known and unknowns are then added to the individual wells and incubated one hour at 37°C (Fig. 6).

The solutions are washed from the wells. Only the antigens/allergens that have receptors (epitopes) to the specific monoclonal antibody bind to the capture monoclonal antibody 8F10.

A second monoclonal antibody having a different epitope specificity than that of the capture monoclonal antibody is biotinylated and used as the detection antibody. Monoclonal antibody 8D9 is diluted to a concentration of 1 mg/ml in 0.1 M

sodium bicarbonate and dialyzed overnight in the same buffer, A 0.1 ml of biotin-X-NHS per ml (Calbiochem) of antibody solution is added and rocked for two hours at room temperature. The coupling reaction is stopped with 0.1 ml of 1 M ammonium chloride per ml of antibody solution and rocked an additional ten minutes at room temperature. The biotinylated 8D9 monoclonal antibody (Biotin-8D9) is then dialyzed against 500 ml of phosphate buffered saline with 0.01% thimersol, pH 7.4, at 4°C with stirring. The 500 ml buffer is replaced the next day and dialysis is allowed to continue for an additional 4 hours. The biotinylated antibody solution is adjusted to 2% with bovine serum albumin as a stabilizer; aliquoted into 0.5 ml fractions; and stored frozen at -70°C. One hundred microliters of the biotinylated 8D9 antibody is then added to each well and incubated overnight at 4°C (Fig. 7). The wells are again washed to remove all of the unbound antibody.

One hundred microliters of a 1:1000 dilution of avidin conjugated horseradish peroxidase enzyme (Vector) is then added to each well for 5 minutes at room temperature (Fig. 8). The biotin on the biotinylated monoclonal antibody and the avidin on the enzyme bind at this stage. The unbound conjugate is washed from the wells.

One hundred microliters of horseradish peroxidase substrate (Citrate buffer, OPD (Sigma),  $H_2O_2$ ; prepared fresh) is added to each well and incubated at room temperature until a color change develops signified by a colorless solution to a brown/orange/yellow color in the wells (approximately 5 - 10 minutes). The color development is stopped with the addition of 100  $\mu$ l of 2N HCL (Fig. 9).

The degree of color development is measured spectrophotometrically (OD490; BioRad plate reader) to determine the absorption. A standard curve is calculated by plotting the concentration of the known peanut concentration  
5 versus the optical density of the reaction in the individual wells. The concentrations of the unknown can then be calculated from this curve by interpolation from the curve reading the optical density and determining the concentration from algebraic equations (Software program with the BioRad  
10 plate reader, Fig. 1).

Other examples of two-site monoclonal antibody enzyme-linked immunosorbent assays in accordance with the present invention include assays using the following MAb pairs: 7B3 and 1B6, 7B3 and 2E9, 7B3 and 6B5, 7B3 and 6F9, 2E9 and  
15 6B5, 2E9 and 6F9, and 2E9 and 8D9. It should be understood that these seven pairs represent fourteen assay examples since each of the MAbs in these pairs can be used as either the capture or detection antibody.

Because each of the above-described monoclonal antibodies  
20 is derived from living hybridoma cells which may perish and since the above description provides one skilled in the art the methodology to produce other hybridoma cells and monoclonal antibodies to the Ara h I peanut allergen, the scope of the present invention is not limited to the named hybridoma cell  
25 lines and monoclonal antibodies derived therefrom.

The two-site monoclonal antibody enzyme-linked immunosorbent assay (ELISA) has many advantages as compared to the conventional radioimmunoassay (RIA). For example, no isotopes or scintillation counters are required, and the



readout may be by eye. The tedious cutting up of trays, loading into tubes, and loading and unloading the counter are all avoided. If a quantitative readout is needed (unnecessary for hybridoma screening) automated reading devices are  
5 available which will scan 96 wells in a minute or so, compared to 1 - 2 h for scintillation counting. Finally, the reagents for ELISA are inexpensive and have a long shelf life. Enzyme-conjugated anti-immunoglobulin or protein A are available commercially from many suppliers. The most commonly  
10 used enzymes are horseradish peroxidase and alkaline phosphatase. Both are capable of giving good results, providing that no endogenous enzyme is present.

## IDENTIFICATION OF ARA H II

Identification and purification of allergens is crucial to the understanding of IgE-mediated disease. Immunologic and structural studies with these purified allergens are the next  
5 steps in unraveling this process. Several allergens have been identified that stimulate IgE production and cause IgE-mediated disease in humans. In comparison with the body of work done to identify and purify inhaled allergens, significantly less work has been done on the food allergens.<sup>1-3</sup> Because peanuts are a  
10 relatively common and often fatal cause of food hypersensitivity reactions we chose to use this model to study IgE-mediated reactions.<sup>4</sup>

Approximately 60% of children with severe atopic dermatitis (AD) have food hypersensitivity reactions.<sup>5,6</sup> The  
15 ability to document food hypersensitivity reactions by double-blind, placebo-controlled, food challenges (DBPCFCs) in this group has allowed appropriate scientific work to be done on the identification of the allergens causing disease.

With the sera of patients who had positive DBPCFCs to  
20 peanut, we were able to begin the process of identification and purification of the major peanut allergens. In our previous study we identified and purified Ara h I, a protein with a mean molecular weight of 63.5 kD and a mean isoelectric point (pI) of 4.55.<sup>7</sup> Identification of a second major peanut allergen,  
25 Ara h II, was accomplished by use of anion-exchange column chromatography, sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE), enzyme-linked immunosorbent assays (ELISAs), thin-layer isoelectric focusing (TLIEF), two-dimensional gel immunoelectrophoresis, IgE-specific

immunoblotting, carbohydrate analysis, amino acid analysis, and sequencing. This protein has a mean molecular weight of 17 kD and a mean pI of 5.2.

#### **Patients sensitive to peanuts**

5 Approval for this study was obtained from the Human Use Committee at the University of Arkansas for Medical Sciences. Nine patients (mean age, 4.2 years) with AD and a positive immediate prick skin test to peanut had either a positive DBPCFC or a convincing history of peanut anaphylaxis (the  
10 allergic reaction was potentially life threatening, that is with laryngeal edema, severe wheezing, and/or hypotension) (7 patients had positive DBPCFCs). Details of the challenge procedure and interpretation have been previously discussed.<sup>8</sup> Five milli-liters of venous blood were drawn from each patient,  
15 allowed to clot, and the serum was collected. An equal volume of serum from each donor was mixed to prepare a nine-person peanut-specific IgE antibody pool.

#### **Crude peanut extract**

Three commercial lots of southeastern runner (*Arachis*  
20 *hypogaea*), medium grade, from the 1979 crop (North Carolina State University) were used in this study. The peanuts were stored in the freezer at -18°C until roasted. The three lots were combined in equal proportions and blended before defatting. The defatting process (defatted with hexane after  
25 roasting for 13 to 16 minutes at 163° to 177°C) was done in the laboratory of Dr. Clyde Young (North Carolina State University). The powdered crude peanut was extracted per the recommendations of Yunginger and Jones<sup>9</sup> in 1 mol/L NaCl to 20 mmol/L sodium phosphate (pH 7.0) with the addition of 8 mol/L

urea for 4 hours at 4°C. The extract was isolated by centrifugation at 20,000 g for 60 minutes at 4°C. The total protein determination was done by the (BCA) method (Bio-Rad Laboratories, Richmond, Calif.).

## 5 Chromatography

Analytic and preparative anion-exchange chromatography was performed with the FPLC system (Pharmacia, Piscataway, N.J.). Anion-exchange chromatography used the PL-SAX column (Anion exchange column, Polymer Laboratories, Amherst, Mass.). The  
10 crude peanut extract was dialyzed against 20 mmol/L Tris-bis-propane (pH 7.2) without urea and 40 mg loaded on the PL-SAX column. A stepwise salt gradient of 0 to 1.5 mol/L NaCl was applied. All fractions of each resolved peak were pooled, dialyzed and lyophilized.

15 Dot blotting was done to determine which fractions from the anion-exchange column chromatogram contained IgE-binding material. Two hundred microliters of each fraction were blotted with the Mini Blot apparatus (Schleicher and Schuell, Keene, N.H.) onto 0.45 um nitrocellulose membranes (Bio-Rad).  
20 After the membranes were dried, the remaining active sites were blocked with 20 ml of blocking solution (0.5% gelatin with 0.001% thimerosal in 500 ml of phosphate-buffered saline [PBS]) for 1 hour. The procedure is then identical to the immunoblotting for IgE.

## 25 Electrophoresis and immunoblotting

The electrophoresis procedure is a modification of Sutton et al.<sup>10,11</sup> SDS-PAGE was carried out with a 12.5% poly-acrylamide separating gel and a stacking gel of 3%. Twenty microliters of a 1 mg/ml solution of each fraction was applied to each well.

Replicate samples were applied for independent analysis. Electrophoresis was performed for 4 hours at 0.030 A per gel (E-C Apparatus Corp., St. Petersburg, Fla.) for the 14 cm by 12 cm gels, and for 1 hour at 175 V per gel for the 8 cm by 7.5 cm gels (Mini-Protean II system, Bio-Rad Laboratories). To assure proper protein separation and visualization, Coomassie brilliant blue (Sigma Chemical Co., St. Louis, Mo.) stains were done on gels. For detection of carbohydrate staining material, gels were stained with the modified PAS stain according to the method of Kapitany et al.<sup>12</sup>

Proteins were transferred from the separating gel to a nitrocellulose membrane in a transfer buffer (tris-glycine) with 10% SDS and 40% methanol.<sup>13</sup> The procedure was done in a transblot apparatus (Bio-Rad Laboratories) for 2 hours (0.150 A). An amido black stain (Bio-Rad Laboratories) was done to assure transfer of the protein.

After removal from the transblot apparatus, the nitrocellulose was placed in blocking solution overnight. The nitrocellulose blot was then washed three times with PBS (PBS with 0.05% Tween 20) and incubated with the pooled peanut-sensitive IgE serum (1:20 dilution) for 2 hours at 4°C with rocking. After washing again with PBS three times, alkaline phosphatase-conjugated goat antihuman IgE (1:1000 vol/vol of PBS, Bio-Rad Laboratories) was added and incubated at room temperature with rocking for 2 hours. After again washing with PBS three times, the blot was developed with 250  $\mu$ l of 30 mg nitro blue tetrazolium in 70% dimethylformamide (NBT) (Bio-Rad Laboratories) and 250  $\mu$ l of 15 mg of 5-bromo-4-chloro-3-indolyl-phosphate in 70% dimethylformamide

(BCIP) (Bio-Rad Laboratories) solutions in 25 ml carbonate buffer (0.2 mol/L, pH 9.8) at room temperature for 15 minutes. The reaction was then stopped by decanting the NBT/BCIP solution and incubating the nitrocellulose for 10 minutes with  
5 distilled water. The blot was air-dried for visual analysis.

#### ELISA for IgE

A biotin-avidin ELISA was developed to quantify IgE antipeanut protein antibodies with modifications from an assay previously published.<sup>14</sup> The upper two rows of a 96-well  
10 microtiter plate (Gibco, Santa Clara, Calif.) were coated with 100  $\mu$ l each of equal amounts (1  $\mu$ g/ml) of antihuman IgE monoclonal antibodies, 7.12 and 4.15 (kindly provided by Dr. A. Saxon). The remainder of the plate was coated with one of the peanut products at a concentration of 1  $\mu$ g/ml in coating  
15 buffer (0.1 mol/L sodium carbonate-bicarbonate buffer, pH 9.5). The plate was incubated at 37°C for 1 hour and then was washed five times with rinse buffer (PBS, pH 7.4, containing 0.05% Tween 20; Sigma Chemicals Co.) immediately and between subsequent incubations. The upper two rows used a secondary  
20 standard reference to generate a curve for IgE, ranging from 0.05 to 25 ng/ml.

The serum pool and patient serum samples were diluted (1:20 vol/vol) and dispensed in duplicate in the lower portion of the plate. After incubation for 1 hour at 37°C and washing,  
25 biotinylated, affinity-purified goat antihuman IgE (KPL, Gaithersburg, Md.) (1:1000 vol/vol PBS) was added to all wells. Plates were incubated for 1 hour at 37°C, washed, and 100  $\mu$ l horseradish peroxidase-avidin conjugate (Vector Laboratories, Burlingame, Calif.) added for 30 minutes. After washing, the

plates were developed by addition of a buffer containing O-phenylenediamine (Sigma Chemical Co.). The reaction was stopped by the addition of 100  $\mu$ l 2-N-hydrochloric acid to each well, and absorbance was read at 492 nm (Titertek Multiscan, 5 Flow Laboratories, McLean, Va.). The standard curve was plotted on log-logit scale by means of simple linear regression, and values for the pool and individual patient samples were read from the curve as "nanogram-equivalent units" per milliliter (nanogram per milliliter).<sup>15,16</sup>

#### 10 ELISA inhibition

A competitive ELISA inhibition was done with the FPLC fractions. One hundred microliters of pooled serum (1:20) from the patients with positive challenges was incubated with various concentrations of the FPLC protein fractions (0.00005 15 to 50 ng/ml) for 18 hours. The inhibited pooled serum was then used in the ELISA described above. The percent inhibition was calculated by taking the food-specific IgE value minus the incubated food-specific IgE value divided by the food-specific IgE value. This number is multiplied by 100 to get the 20 percentage of inhibition.

#### Isoelectric focusing

The samples were focused with the LKB Multiphor system using LKB PAG plates, pH gradient 3.5 to 9.5 (LKB, Bromma, Sweden). Five microliters of sample (1 mg/ml) was applied, and 25 an electric current of 200 V was applied for 30 minutes and then increased to 900 to 1200 V for 30 minutes. The gel was fixed and stained with Coomassie brilliant blue following the standard protocol (LKB).

### Two-dimensional gel electrophoresis

The samples were run according to the method of O'Farrell et al.<sup>17</sup> The first dimension is an isoelectric focusing gel in glass tubing. After making the gel mixture the samples are loaded with overlay solution and 0.02 mol/L NaOH. The samples are run at 400 V for 12 hours and at 800 V for 1 hour. After removing the gel from the tube, the isoelectric focusing gel is equilibrated for 2 hours in SDS sample buffer. The second dimension is 14 cm by 12 cm, 12.5% polyacrylamide gel described in the electrophoresis section. The gels were stained with the pooled peanut-positive serum for IgE-specific bands as above. Amino acid analysis, amino acid sequencing, and carbohydrate analysis

The 17 kD fraction was run on a 10% mini-gel (Bio-Rad Laboratories) in Tris-glycine buffer and stained with Rapid Reversible Stain (Diversified Biotech, Newton Centre, Mass.). The two bands were cut separately from the gel and electroluted in tris-glycine SDS buffer. After lyophilization the bands were sequenced individually. Automated gas-phase sequencing was performed on an Applied Biosystems model 475A sequencing system (Dr. Bill Lewis, University of Wyoming, Laramie, Wyo.). Amino acid analysis was done with a Hitachi (Hitachi Instruments, Inc., Danbury, Conn.) HPLC L5000 LC controller with a C18 reverse-phase column.

The electroluted 17 kD fraction was analyzed for carbohydrate analysis (Dr. Russell Carlson, Complex Carbohydrate Research Center, University of Georgia, Athens, Ga.). Glycosyl composition analysis on these samples was performed by the preparation and analysis of trimethylsilyl



methylglycosides.

## RESULTS

### Chromatography

Pilot experiments were conducted with the analytical  
5 Mono Q 5/5 (Pharmacia) anion-exchange column to determine the  
optimal buffer system and salt gradient. Screening for IgE-  
specific peanut binding components was done by dot blotting of  
these fractions. Scale up and optimization was completed with  
the PL-SAX column (anion-exchange), with a stepwise salt  
10 gradient (0 to 1.5 mol/L NaCl). This procedure separated the  
crude peanut extract into seven major peaks (Fig. 10).  
Preliminary dot blotting from this separation identified  
IgE-binding material in each peak (picture not shown).  
Multiple runs of this fractionation procedure were performed,  
15 and each isolated peak was pooled, dialyzed against 100 mmol/L  
NH<sub>4</sub>HCO<sub>3</sub>, and lyophilized.

### Electrophoresis and immunoblotting

Initial SDS-PAGE and immunoblotting of the crude peanut  
extract revealed multiple fractions with several IgE-staining  
20 bands.<sup>7</sup> Aliquots of the seven lyophilized fractions from the  
anion-exchange column were analyzed by SDS-PAGE (date not  
shown). Each fraction showed 2 to 5 Coomassie brilliant blue  
staining protein bands. Immunoblotting for specific IgE with  
the pooled serum revealed IgE-staining bands in each fraction.  
25 Fraction 4 showed two large, closely migrating, IgE-specific  
bands with a mean molecular weight of 17 kD (Fig. 11) (6% by  
weight of crude peanut extract).

**ELISA and ELISA inhibition**

ELISA results comparing the crude peanut extract with each isolated fraction are shown in Fig. 12. Fractions 1 through 7 all had IgE-binding from the peanut-positive serum pool. We tested individually the serum of six patients (members of pooled serum) to determine the relative IgE-binding material to both the crude peanut, fraction 4 (which contained the 17 kD component), and Ara h I (major component, 63.5 kD fraction). Each patient's serum had measurable amounts of peanut-specific IgE to each. Three of the patients had more peanut-specific IgE (nanogram/milliliter) to the 17 kD fraction than to the 63.5 kD fraction (Table 10).

The ELISA inhibition results are shown in Fig. 13. The concentration of the 17 kD fraction required to produce 50% inhibition was 0.4 ng/ml compared with 0.1 ng/ml of the crude peanut extract.<sup>18</sup>

**Two-dimensional gel electrophoresis**

Because immunoblotting and ELISAs of the various anion-exchange fractions suggested that fraction 4 appeared to contain a major allergen, isoelectric focusing was done on this fraction. The two bands in this allergen, which migrated closely together at a mean molecular weight of 17 kD on SDS-PAGE stained with Coomassie brilliant blue, had a pI of 5.2 (gel not shown). Fig. 14 shows the Coomassie-stained gel of the 17 kD fraction. One can see the protein divided into four distinct areas at a mean molecular weight of 17 kD and a mean pI of 5.2.

### Amino acid analysis, amino acid sequencing, and carbohydrate analysis

Table 11 shows the complete amino acid analysis of the purified peanut fraction. The fraction was particularly rich  
5 in glutamic acid, aspartic acid, glycine, and arginine.

The amino acid sequence for both 17 kD bands is shown in Table 12. The sequence for the second 17 kD band was essentially identical. Molecular weight discrepancies may be a result of carbohydrate composition in the two isoallergens.  
10 There are no known similar N-terminal sequences found in PIR, GEN-BANK, or SWISS-PROTEIN.

The 17 kD fraction was found to be 20% carbohydrate with significant levels of galacuronic acid, arabinose, and xylose (Table 13).

### 15 DISCUSSION

Individuals are genetically prone to produce IgE to specific antigens and to have allergic disease. No known features have been found to distinguish allergens as unique antigens.<sup>19</sup> The route of allergen administration, the dosage,  
20 the frequency of exposure, and genetic factors all determine the type and severity of the individual's allergic response. Three seemingly distinct foods account for approximately 80% of positive food challenges in children.<sup>5-7</sup> It is apparent that in addition to the fact that these foods are consumed frequently  
25 in the diet of children, other factors in either the allergen (food) itself or in the processing of these allergens cause these foods to be responsible for most food hypersensitivity reactions.

Most allergens are low molecular weight proteins or glycoproteins (5 to 50 kD).<sup>20</sup> Recent knowledge about the amino acid sequence of known allergens has not revealed any special features that would be associated with IgE antibody formation.<sup>19</sup>

5 To first identify and then purify the allergens is crucial to a better understanding of the allergic response. Various biochemical techniques have been used to purify allergens from pollen, mite, and animal dander. These techniques include gel filtration, anion-exchange chromatography, and isoelectric  
10 focusing.<sup>19</sup> Recent advances in chromatography, including the FPLC (Pharmacia) and immunoaffinity columns with monoclonal antibodies specific for the purified allergens, has allowed easier and faster identification and purification of allergens.

House dust mite, ragweed, and venom allergens are among  
15 those allergens that have been isolated and well characterized. Food allergens have been less studied. The food allergens that have been identified and characterized include Gad c I (cod), Gal d II (ovalbumin), and antigen I (shrimp).<sup>1,2</sup>

Because of the prevalence and severity of adverse  
20 reactions to peanuts, several previous studies have examined the possibly relevant peanut allergens.<sup>21-27</sup> Multiple molecular weight peanut proteins have been identified from these various studies. Meier-Davis et al.<sup>24</sup> identified three major allergenic fractions, one of which had a molecular weight of 15 kD, which  
25 is close to the molecular weight of the allergen Ara h II we have identified. No further identification or characterization of this protein is available.

In a previous study we identified Ara h I, a 63.5 kD allergen from peanuts with a pI of 4.55.<sup>7</sup> This allergen was

similarly purified and identified with a combination of anion-exchange chromatography, SDS-PAGE, ELISA, TLIEF, and ELISA inhibition. The allergen described in this report has two major bands, with an apparent mean molecular weight of 17 kD on  
5 SDS-PAGE and a mean pI of 5.2. This fraction bound specific anti-peanut IgE from the peanut-positive pool in the ELISA and in the immunoblotting experiments. When used in the ELISA-inhibition studies, the 17 kD fraction significantly inhibited the IgE binding from the peanut-positive pool. In preliminary  
10 studies we have used the 17 kD allergen to inhibit binding from the pooled peanut-positive IgE serum to our previously described Ara h I. There does appear to be a moderate amount of inhibition of IgE binding to Ara h I produced by the 17 kD allergen. Amino acid sequencing of Ara h I will help to  
15 resolve the identity of similar epitopes for IgE between the unique allergens.

According to recent recommendations by a recent international committee (IUIS) for proper identification of allergens we have designated this fraction Ara h II.<sup>20</sup> This  
20 fraction has been purified from a crude peanut extract from Florunner peanuts (*Arachis hypogaea*) by anion-exchange chromatography. The fraction was identified as a major allergen by SDS-PAGE, ELISA, ELISA inhibition, TLIEF, amino acid analysis and sequencing, carbohydrate analysis, and  
25 two-dimensional gels.

As we have previously speculated, Ara h II is likely to be the second of several major and minor allergens isolated from peanuts. The identification of the allergenic components in foods will allow new studies to elucidate more comprehensively

the body's immune response to these allergens. Future work in this area will be directed toward molecular identification and characterization of both B- and T-cell epitopes.

In accordance with the present invention, isolated and  
5 purified peanut allergen Ara h II is used as an antigen to produce monoclonal antibodies having a specificity for the Ara h II allergen and to develop a monoclonal antibody enzyme linked immunosorbent assay for the peanut allergen Ara h II using the same methods and procedures as described above with  
10 respect to the development of monoclonal antibodies and assays for the peanut allergen Ara h I. In accordance with one example of the present invention, a method for detecting the presence and quantity of the peanut allergen Ara h II in a sample using a two-site monoclonal antibody enzyme linked  
15 immunosorbent assay includes the steps of: coating an assay test surface with a layer of capture monoclonal antibodies having a specificity for the Ara h II allergen, incubating the coated test surface to allow the capture monoclonal antibodies to adhere to the test surface, washing the coated test surface  
20 to remove any unadhered capture monoclonal antibodies, adding a sample to the coated test surface, incubating the coated test surface to allow the adhered capture monoclonal antibodies to capture any Ara h II peanut allergen present in the sample, washing the coated test surface to remove the uncaptured peanut  
25 allergen and remaining sample, adding a layer of biotinylated monoclonal antibodies having a specificity for the Ara h II allergen to the coated test surface, incubating the coated test surface to allow the biotinylated monoclonal antibodies to bind to the captured peanut allergen, washing the coated test

surface to remove unbound biotinylated monoclonal antibodies, adding horseradish peroxidase-avidin conjugate to the coated test surface, allowing the horseradish-peroxidase, avidin conjugate to bind to the biotinylated monoclonal antibodies, washing the coated test surface to remove any unbound horseradish peroxidase-avidin conjugate, adding citric acid substrate to the coated test surface to develop a color change indicative of the quantity of bound horseradish peroxidase, adding a stopping agent to stop the development of the color change, and reading the assay to determine the presence and/or quantity of the peanut allergen Ara h II. Also, in accordance with a more particular method, the capture monoclonal antibodies and biotinylated monoclonal antibodies demonstrate specificity for different binding sites on the peanut allergen Ara h II.

Moreover, in accordance with another embodiment of the present invention, test kits for detecting and quantifying the peanut allergens Ara h I and Ara h II include an ELISA test tray, the capture and biotinylated monoclonal antibodies, allergen standards, and the necessary reagents for practicing the described assay method.

Thus, it will be appreciated that as a result of the present invention, two major peanut allergens have been isolated and a highly effective two-site monoclonal antibody enzyme-linked immunosorbent assay and method is provided by which the principal objective, among others, is completely fulfilled. It is contemplated, and will be apparent to those skilled in the art from the preceding description and accompanying drawings, that modifications and/or changes may be

made in the illustrated embodiments without departure from the present invention. Accordingly, it is expressly intended that the foregoing description and accompanying drawings are illustrative of preferred embodiments only, not limiting, and  
5 that the true spirit and scope of the present invention be determined by reference to the appended claims.



## LIST OF ABBREVIATIONS

DBPCFC:	Double-blind, placebo-controlled, food challenge
SDS:	Sodium dodecyl sulfate
PAGE:	Polyacrylamide gel electrophoresis
NBT:	30 mg nitro blue tetrazolium in 70% dimethylformamide
BCIP:	15 mg of 5-bromo-4-chloro-3-indolyl-phosphate in 70% dimethylformamide
TLIEF:	Thin-layer isoelectric focusing
ELISA:	Enzyme-linked immunosorbent assay
AD:	Atopic dermatitis
pI:	Isoelectric point
CRIE:	Crossed radioimmuno-electrophoresis
Ab:	Antibody
IUIS:	International Union of Immunological Societies
FPLC:	Fast protein liquid chromatography
PAS:	Periodic acid-Schiff
MAb:	Monoclonal antibody
IEF:	Isoelectric focusing
Con A:	Concanavalin A
PBS:	Phosphate-buffered saline
RIA:	Radioimmunoassay

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TABLE 1

Individual IgE-antibody to peanut allergens (ng/ml)

<u>Pt</u>	<u>Crude peanut</u>	<u>Ara h Ii</u>	<u>Ara h I</u>
#1	4.2	21.0	14.6
#2	7.0	11.4	13.0
#3	285.2	285.8	380.0
#4	1.0	2.0	3.2
#5	11.4	19.4	17.0
#6	5.8	12.0	9.8
Normals (x2)	<0.05	<0.05	<0.05

TABLE 2

ELLISA inhibition for 7 monoclonal antibodies to Ara h I

Inhibiting antibody

8F10 8D9 2E9 7B3 1B6 6B5 6F9 Alt 1

Biotinylatedmonoclonal

8F10	71%	10%	11%	11%	2%	5%	5%	0%
8D9	31%	82%	34%	0%	28%	26%	5%	0%
2E9	26%	35%	53%	15%	29%	27%	10%	0%
7B3	22%	4%	0%	50%	16%	13%	10%	0%
1B6	0%	43%	39%	0%	55%	34%	6%	0%
6B5	22%	52%	35%	18%	52%	75%	8%	0%
6F9	20%	20%	12%	12%	35%	27%	54%	0%

TABLE 3

## SAMPLES

<u>Peanut</u>	<u>Others</u>	<u>Oils</u>
Plain M&M	Twix	Olive
Peanut M&M	Skor	Garlic
Whatchamacalit	Nestle Crunch	Vegetable
Snickers	3 Musketeers	Canola
Peanut Butter M&M	Kit Kat	Corn
		Peanut

TABLE 4

## 63.5 Kd Two-site Immunometric Assay (Candy)

<u>Peanut</u>	<u>(ng/ml)</u>	<u>Others</u>	<u>(ng/ml)</u>
Plain M&M	7.35	Twix	0
Snickers	219.00	Skor	0
Peanut M&M	221.00	Nestle Crunch	0
Whatchamacalit	233.00	3 Musketeers	0
Peanut Butter M&M	299.00	Kit Kat	0

TABLE 5

## 63.5 kD Two-site Immunometric Assay

<u>Oils</u>	<u>(ng/ml)</u>
Olive	0
Garlic	0
Vegetable	0
Canola	0
Corn	0
Peanut	0

TABLE 6

Individual IgE Ab to peanut allergens (nanograms per milliliter)

Patient	Crude peanut	63.5 kd
1	4.21	4.6
2	7.0	13.0
3	285.2	380.0
4	1.0	3.2
5	11.4	17.0
6	5.8	9.8
7	ND	ND
8	ND	ND

TABLE 7

ELISA - IgE (pooled peanut positive serum)

PROTEIN	CAPTURE ANTIBODY			
	8D9	8F10	2E9	7B3
Peanut Positive IgE Serum Pool				
63.5 kD fraction	4+	4+	4+	4+
crude peanut	4+	4+	4+	4+
17 kD fraction	2+	2+	2+	2+
soy	0+	0+	0+	0+
peas	1+	1+	1+	1+
chick peas	1+	1+	1+	1+
green beans	0+	0+	0+	0+
lima beans	0+	0+	0+	0+
ovalbumin	0+	0+	0+	0+
Normal serum pool				
crude peanut	0+	0+	0+	0+
63.5 kD fraction	0+	0+	0+	0+

Table 7. We examined various proteins in the two-site immunometric assay with the mAb as the capture antibody and the peanut positive IgE serum pool as the second antibody. Table 7 shows the results of this assay. The binding was graded from 0+ (none) to 4+ (significant).

TABLE 8

IgE (individual peanut positive serum)

	CAPTURE ANTIBODY			
	8D9	IF10	2E9	7B3
<b>PATIENTS</b>				
#1	38%	28.3%	35.3%	32.3%
#2	227.8%	156%	282.2%	164.3%
#3	61.6%	82.9%	38.7%	27.4%
#4	18.2%	14.4%	13.6%	13.1%
#5	21.2%	24.8%	38%	23.1%
#6	57.8%	71.9%	56%	64.8%
Peanut positive pool	165%	144%	125.7%	143%
#7	7.1%	7.4%	0.0%	0.0%
#8	7.1%	1.8%	4.5%	3.5%

Table 8. Table 8 shows the results of individual peanut positive patients in a similar two-site assay. Patients with normal serum IgE (#7) or patients (#8) with elevated serum IgE but who were not challenge positive to peanut.



TABLE 9Site specificity of Ara *h* I monoclonal antibodies

(a)	A 8F10	B 8D9 2E9 1B6 7B3	C 7B3	D 6F9
(b)	X	Y		Z
	8F10	8D9 6B5		6F9

TABLE 10 Concentrations (ng/ml) of peanut-specific IgE binding to the crude peanut extract, Ara h I (63.5 kd allergen), and fraction 4 (from FPLC) (17 kd allergen)

Patient	Crude peanut (ng/ml)	Ara h I (ng/ml)	Fraction 4 (ng/ml)
1	4.2	21.0	14.6
2	7.0	11.4	13.0
3	285.2	285.8	380.0
4	1.0	2.0	3.2
5	11.4	19.4	17.0
6	5.8	12.0	9.8
7	<0.05	<0.05	<0.05
8	<0.05	<0.05	<0.05
Normals	<0.05	<0.05	<0.05

TABLE 11 Amino acid analysis of Ara h II

Amino acid	Residues/molecule
Asp	12.2
Glu	24.8
Ser	9.8
His	1.3
Gly	11.3
Thr	2.2
Arg	10.8
Ala	5.4
Tyr	3.9
Met	2.7
Val	2.4
Phe	2.4
Ile	2.9
Leu	7.9

TABLE 12 Sequencing of upper and lower bands of electroluted 17 kd peanut allergen

Upper Band	*	-	-	Gln	-	Gln	-	-	Gln	-	-	Glu	-	Leu	-	Gln	-	*	-	Asp	-	*	-	*
Lower Band	*	-	-	Gln	-	Gln	-	*	-	-	-	Glu	-	Leu	-	Gln	-	-	-	Asp	-	Glu	-	*
Upper Band	-	Gln	-	Ser	-	Gln	-	Leu	-	-	-	Glu	-	Arg	-	Ala	-	Asp	-	Leu	-	Arg	-	Pro
Lower Band	-	Gln	-	Ser	-	Gln	-	Leu	-	-	-	Glu	-	Asp	-	Ala	-	Asn	-	Leu	-	Arg	-	Pro
Upper Band	-	Glu	-	Gln	-	Gln	-	-	-	-	Met	-	Leu	-	-	-	-	Lys	-	Ile	-	-	-	-
Lower Band	-	Glu	-	Gln	-	Gln	-	-	-	-	Met	-	Leu	-	-	-	-	Lys	-	Ile	-	-	-	-

\*Unable to identify amino acid.

TABLE 13 Glycosyl composition analysis of 17 kd allergen

Glycosyl residue	Ara h II ( $\mu$ g/total)
Arabinose	14.0
Rhamose	2.8
Fucose	0.58
Xylose	9.3
Mannose	2.5
Galactose	4.4
Glucose	5.0
Galacuronic acid	41.0
Galactosamine	ND
ND, None detected.	

Peanuts are a common cause of food hypersensitivity reactions. The sera of 10 patients who had atopic dermatitis and a positive double-blind placebo-controlled food challenge to peanut were used to investigate the major allergens of peanut. Crude Florunner extracts were fractionated by anion-exchange chromatography using a step gradient (limit buffer, 0.05M BisTris/1.5M NaCl). One hundred microliters of each 2.0 ml fraction was dot-blotted onto nitrocellulose paper and IgE-binding activity assessed using the serum pool to select allergen-containing fractions. A protein peak (OD 280) which eluted at 10% NaCl and demonstrated intense IgE-binding was further analyzed by two-dimensional SDS-PAGE/immunoblot analysis. The majority of this fraction is a protein which has a molecular weight of 17 kD and a pI of 5.2. Sequencing data from the N-terminus revealed the following initial 9 amino acids: (\*)-Q-Q-(\*)-E-L-Q-D-L. Based on IgE-binding activity and no known amino acid sequence identity to other allergens, this allergen is designated Ara h II.

#### Figure Legends

FIG. 1 - Logit: Abs vs. Log (conc)

FIG. 2 - Anion exchange chromatogram of the defatted crude peanut extract fractionated over the FPLC Mono Q 10/10. The elution pattern of proteins ( $A_{280}$ ) is illustrated by the *solid line*. A stepwise salt gradient of 0 to 1.5 mol/L of NaCl is illustrated by the *dotted line*. Fractions were pooled as numbered (fraction 2 is divided into 2a and 2b) and applied to SDS-PAGE for analysis.

FIG. 3 - Antipeanut IgE-specific ELISA (nanograms permilliliter) to the defatted crude peanut extract and the pooled fractions from the anion-exchange column. The results are from the peanut-positive serum pool.

5 FIG. 4 - IgE ELISA-inhibition results of crude peanut extract and anion-exchange fraction 3 (63.5 kd fraction) in ELISA for crude peanut.

FIG. 10 - Anion-exchange chromatogram of the defatted crude peanut extract fractionated over the FPLC PL-SAX column. Elution pattern of proteins ( $A_{280}$ ) shown by the *solid line*. Stepwise salt gradient of 0 to 1.5 mol/L NaCl shown by the *dotted line*. Fractions were pooled as numbered and applied to SDS-PAGE for analysis.

FIG. 11 - SDS-PAGE (14 cm x 12 cm) analysis of the defatted crude peanut extract stained with Coomassie brilliant blue (lane 1) and immunoblotted for antipeanut specific IgE (lane 2) with pooled serum from patients with AD and positive DBPCFCs to peanut. Molecular weights: 1, 50,000; 2, 39,000; 3, 27,500; 4, 14,500.

20 FIG. 12 - Antipeanut IgE-specific ELISA (ng/ml) to defatted crude peanut extract and pooled fractions from the anion-exchange column. Results are from the peanut-positive serum pool.

FIG. 13 - IgE ELISA inhibition results of crude peanut extract and anion-exchange fraction 4 in the ELISA for crude peanut.

FIG. 14 - Coomassie brilliant blue stain of two-dimensional gel with fraction 4 (anion exchange column) containing the 17 kd allergen. Molecular weights: 1, 112,000;

2, 75,000; 3, 50,000; 4, 39,000; 5, 27,500; 6, 17,000. With respect to Table 12, the upper band corresponds to SEQ ID NO:1, and the lower band corresponds to SEQ ID NO:2.

Sequencing data from the N-terminus of the lower band  
5 revealed the following initial 9 amino acids: (\*)-Q-Q-(\*)-E-L-Q-D-L (SEQ ID NO:3).

**RECOMBINANT PEANUT ALLERGEN Ara h I EXPRESSION AND IgE BINDING  
IN PATIENTS WITH PEANUT HYPERSENSITIVITY**

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## INTRODUCTION

Peanut allergy is a significant health problem because of the potential severity of the allergic reaction, the chronicity of the allergic sensitivity, and the ubiquity of peanut products. Peanuts, fish, tree nuts, and shellfish account for the majority of food hypersensitivity reactions in adults, while peanuts, milk, and eggs cause over 80% of food hypersensitivity reactions in children (1,2). Peanut hypersensitivity reactions often tend to be quite severe in nature, sometimes resulting in episodes of fatal anaphylaxis (3,4). Unlike the food hypersensitivity reactions to milk and eggs, peanut hypersensitivity reactions usually persist into adulthood and last for a lifetime (5). Despite the significant prevalence of peanut hypersensitivity reactions and several fatalities annually, the identification of the clinically relevant antigens and an understanding of the immunobiology of peanut hypersensitivity is just beginning (6).

Recently a number of allergens have been identified which stimulate IgE production and cause IgE mediated disease (7). The identification and purification of these allergens is essential for the immunological studies necessary to understand their role in stimulating IgE antibody formation. Significant information now exists on the identification and purification of inhaled allergens from pollens, dust mites, animal danders, insects, and fungi (7). By comparison, few food allergens known to cause IgE-mediated reactions have been similarly identified and purified (8-10).

Recombinant methodology to clone allergens provides an efficient means of producing pure polypeptides which, in their native source, form complex mixtures and are often represented in only very small amounts. Several inhaled allergens have  
5 been cloned, including the allergens of house dust mites (11) and pollen grains (12), in comparison little work has been directed toward producing recombinant food allergens.

Because of the prevalence and severity of peanut hypersensitivity reactions in both children and adults, coupled  
10 with the recent identification of two major peanut allergens that are involved in this process (6,13), we set out to clone and characterize the Ara h I peanut allergen. In this communication we report the isolation and characterization of the Ara h I mRNA and the identification of this allergen as  
15 belonging to the vicilin seed storage protein family. In addition, this recombinant allergen can be produced in *E. coli* cells and is recognized by serum IgE from patients with documented peanut hypersensitivity reactions.

**METHODS**

**Patients.** Serum from eighteen patients with documented peanut hypersensitivity (mean age - 25 years) was used to identify peanut allergens. Each of these individuals had a positive  
5 immediate prick skin test to peanut and either a positive double blind, placebo controlled, food challenge (DBPCFC) or a convincing history of peanut anaphylaxis (laryngeal edema, severe wheezing, and/or hypotension). One individual with elevated serum IgE levels (who did not have peanut specific IgE  
10 or peanut hypersensitivity) was used as a control in these studies. Details of the challenge procedure and interpretation have been discussed previously (6). At least five mls of venous blood were drawn from each patient and allowed to clot, and the serum was collected. All studies were approved by the  
15 Human Use Advisory Committee at the University of Arkansas for Medical Sciences.

**Isolation and Amino Acid Sequence Analysis of Peanut Allergen Ara h I.** Ara h I was purified to near homogeneity from whole peanut extracts according to the methods of Burks et al (6).  
20 Purified Ara h I was electrophoresed on 12.5% acrylamide mini-gels (Bio-Rad, Hercules, CA) in Tris glycine buffer. The gels were stained with 0.1% Coomassie blue in 10% acetic acid, 50% methanol, and 40% water for 3 hours with continuous shaking. Gel slices containing Ara h I were sent to the W.M. Keck  
25 Foundation (Biotechnology Resource Laboratory, Yale University, New Haven, CT) for amino acid sequencing. Initial sequencing indicated that the amino terminal end of Ara h I was blocked. In order to obtain protein sequencing data Ara h I was treated

with trypsin and peptides were selected for further analysis. Amino acid sequencing of tryptic peptides was performed on an Applied Biosystems sequencer with an on-line HPLC column that was eluted with increasing concentrations of acetonitrile.

5 ***Peanut RNA Isolation and Northern (RNA) Gels.*** Three commercial lots from the 1979 crop of medium grade peanut species, *Arachis hypogaea* (Florunner) were obtained from North Carolina State University for this study. Total RNA was isolated from one gram of this material according to procedures described by  
10 Larsen (14). Poly A+ RNA was isolated using a purification kit supplied by Collaborative Research (Bedford, MA) according to manufacturer's instructions. Poly A+ RNA was subjected to electrophoresis in 1.2% formaldehyde agarose gels, transferred to nitrocellulose, and hybridized with <sup>32</sup>P-labeled probes  
15 according to the methods of Bannon et al (15).

***cDNA Expression Library Construction and Screening.*** Peanut poly A+ RNA was used to synthesize double stranded cDNA according to the methods of Watson and Jackson (16) and Huynh et al (17). The cDNA was treated with Eco R1 methylase and  
20 then ligated with Eco R1 and Xho I linkers. The DNA was then ligated with Eco R1-Xho I cut, phosphatase treated Lambda ZAP XR phage arms (Stratagene, LaJolla, CA) and *in vitro* packaged. The library was 95% recombinants carrying an average insert size of >400 bp as determined by sizing of randomly selected  
25 clones. The library was screened using an IgE antibody pool consisting of an equal volume of serum from each patient with peanut hypersensitivity. Detection of the primary antibody was

either with alkaline phosphatase labeled anti-IgE or  $I^{125}$ -labeled anti-IgE antibody performed according to manufacturer's instructions. Positive plaques were subjected to subsequent screens using the same pooled serum until all non-reacting  
5 plaques were removed. The remaining positive plaques were then re-screened with serum from a patient with elevated total serum IgE who did not have peanut specific IgE to ensure that we were not isolating non-specific, IgE binding clones.

**PCR Amplification of the Ara h I mRNA Sequence.** Using the  
10 oligonucleotide GA(TC)AA(AG)GA(TC)AA(TC)GTNAT.(TCA)GA(TC)CA derived from amino acid sequence analysis of the Ara h I (63.5 kD) peanut allergen as one primer and a 27 nucleotide long oligo dT stretch as the second primer a portion of the nucleotide sequence that encodes this protein was amplified  
15 from peanut cDNA. Reactions were carried out in a buffer containing 3 mM  $MgCl_2$ , 500 mM KCl, 100 mM Tris-HCl, pH-9.0. Each cycle of the polymerase chain reaction consisted of one minute at 94°C, followed by two minutes at 42°C, and three minutes at 72°C. Thirty cycles were performed with both  
20 primers present in all cycles. From this reaction a 400 bp fragment was amplified and subsequently cloned into a TA vector by standard protocols (Promega, Madison, WI).

**DNA Sequencing and Analysis.** Sequencing was done according to the methods of Sanger et al (18) using a series of clones  
25 constructed by Exo III digestion of the original DNA isolate or oligonucleotide primers directed to different regions of the clone. Sequence analysis was done on the University of

Arkansas for Medical Science's Vax computer using the Wisconsin DNA analysis software package.

*Production of Recombinant Ara h I Protein.* The Ara h I cDNA was ligated into the Eco R 1 site of a pBluescript vector (Stratagene, LaJolla, CA). This vector contains 111 nucleotides of the Beta galactosidase gene prior to the Eco R1 site. When *E. coli* JM109 cells carrying this construct are induced with IPTG they produce a fusion protein consisting of 37 amino acids derived from Beta galactosidase followed by the Ara h I protein. Exponentially growing cells are induced with 1 mM IPTG for 4 hrs at 37°C. Cells are then pelleted and resuspended in SDS-sample buffer, placed in a boiling water bath for 5 minutes and then either used immediately for immunoblot analysis or stored at -20°C until needed.

*IgE Immunoblot Analysis.* SDS-polyacrylamide gel electrophoresis was performed by the method of Laemmli (19). All gels were composed of a 10% acrylamide resolving gel and 4% acrylamide stacking gel. Electrophoretic transfer and immunoblotting on nitrocellulose paper were performed by the procedures of Towbin et al (20). The blots were incubated with antibodies diluted in a solution containing TBS and 1% bovine serum albumin for at least 12 hr at 4°C or for 2 hours at room temperature. Detection of the primary antibody was with I<sup>125</sup>-labeled anti-IgE antibody.

**RESULTS**

*Isolation and Partial Amino Acid Sequence Determination of Peptides Derived From the Ara h I Protein.* Purified Ara h I protein was treated with trypsin and the peptide products  
5 separated from one another by high performance liquid chromatography. Three peptide fractions, selected on the basis of their separation from each other and other fractions in the mix, were used for amino acid sequence determination. During the course of sequencing it was noted that fraction I and III  
10 consisted of a single peptide species (peptide I and peptide III, respectively). Fraction II consisted of one major peptide (peptide II) with numerous minor peptide contaminants which complicated sequence determination. However, it was possible to determine the first 16 residues of the major peptide in  
15 fraction I and II and the first 10 residues of the major peptide in fraction III. The amino acid sequence determined for each peptide is noted in Table 14.

*Isolation of Clones That Produce Antigens Recognized By Peanut Specific IgE From Patients With Peanut Hypersensitivity.* RNA  
20 isolated from the peanut species, *Arachis hypogaea* (Florunner) was used to construct an expression library for screening with serum IgE from patients with peanut hypersensitivity. Numerous IgE-binding clones were isolated from this library after screening  $10^6$  clones with serum IgE from a pool of patients  
25 with reactivity to most peanut allergens by western blot analysis. Since the number of plaques reacting with serum IgE was too large to study all in detail we randomly selected a small portion of the positive plaques for further purification.

Phage positive for IgE binding were plaque purified to homogeneity and then tested for their ability to react with serum IgE collected from a patient without peanut hypersensitivity. All of the selected clones were intensely  
5 positive when incubated with serum IgE from patients with peanut hypersensitivity. In contrast, these same clones did not react with control serum IgE. These results show that we have isolated numerous clones capable of producing IgE recognizable antigens specific to patients who have peanut hypersensitivity.

10 **Identification and Characterization of Clones That Encode Peanut Allergen Ara h I.** To help identify which of the many IgE positive clones encoded the Ara h I allergen, a hybridization probe was constructed using an oligonucleotide developed from Ara h I amino acid sequence and PCR technology. The  
15 oligonucleotide sequence  
GA(TC)AA(AG)GA(TC)AA(TC)GTNAT(TCA)GA(TC)CA was derived from amino acid residues located within peptide I (Table 14) of the Ara h I peanut allergen. Utilizing this oligonucleotide as one primer and a 27 nucleotide oligo dT stretch as the second  
20 primer a portion of the mRNA sequence that encodes this protein was amplified from peanut cDNA. This 400 bp DNA fragment was subsequently cloned and sequenced by the Sanger dideoxy (18) method. DNA sequence analysis revealed that the 400 bp DNA fragment contained a poly A stretch on one end and the Ara h I  
25 specific nucleotide sequence on the other end. In addition, this clone contained nucleotide sequence correctly encoding the remaining carboxy terminal portion of peptide I. Thus, an Ara h I specific clone has been isolated and it can be used as a



hybridization probe to identify which of the many IgE positive clones selected encodes the Ara h I allergen.

We hybridized a Southern blot containing four of the IgE selected cloned DNAs with a <sup>32</sup>P-labeled, Ara h I PCR  
5 amplification product to determine which of the isolated clones encoded the Ara h I peanut allergen. All of the clones were positive for hybridization with this probe. In addition we screened 200,000 clones from the peanut cDNA library using <sup>32</sup>P-labeled Ara h I clone as a probe. From this screen, over 100  
10 Ara h I positive clones were identified (data not shown). These results indicate that the mRNA encoding the Ara h I allergen is an abundant message within this library.

In order to determine what size mRNA these clones identify, <sup>32</sup>P-labeled insert from one of the largest cDNA  
15 clones (41B) was used as a hybridization probe of a Northern blot containing peanut poly A+ RNA (Fig.15). This insert hybridized to an ~2.3 kb mRNA indicating that this insert probably represented the entire mRNA.

***Peanut Allergen Ara h I is a Vicilin-Like Seed Storage Protein.***

20 The primary DNA sequence of two of the largest cDNA clones selected (41B and P17) was determined by Sanger dideoxy sequencing using oligonucleotide primers directed to different regions on the insert or a series of subclones constructed by Exo III digestion of the inserts. Clone 41B carried a 2,050  
25 base insert while clone P17 carried a 1,972 base insert. The first ATG protein synthesis start codon was located at nucleotide position 50-53. The sequence around this codon agrees with the translation initiation sequence found in most

eukaryotic mRNAs (21). Each of the inserts contained a large open reading frame starting with this codon and ending with a TGA codon at nucleotide position 1928-1930. Overall, there was greater than 97% DNA sequence homology between the two inserts.

5 Both clones were capable of encoding a protein of ~68 kD. The amino acid sequence that was determined from Ara h I peptides I and III is found in both of these clones. The only difference between the derived and predicted amino acid sequence of both clones occurs at position seven of peptide II  
10 in clone P17. At this position there is a glycine residue in the peptide that is missing in the P17 DNA sequence. In addition, both proteins have a signal peptide at the amino terminus (22) and a single glycosylation addition site (NAS) at amino acid position 521-523. These data confirm and extend our  
15 conclusion that these clones encode the Ara h I allergen (Fig. 16).

A search of the GenBank database revealed significant sequence homology between the Ara hI cDNA clones and a class of seed storage proteins called vicilins. There was 60-65%  
20 homology over greater than 750 bases when the Ara h I DNA sequences were compared with the broad bean and pea vicilins (Table 15). These results indicate that the Ara h I allergen belongs to a vicilin-like multi-gene family encoding very similar but not identical proteins.

25 **Recognition of Recombinant Ara h I by Patient Sera in an IgE Immunoblot Assay.** IgE immunoblot analysis was initially performed using serum IgE from a pool of patients with peanut hypersensitivity to determine the molecular weight of the

recombinant protein and the specificity of the IgE recognition reaction. Figure 17 (lanes A and B) shows that the IgE pool recognized whole peanut extract and purified native Ara h I protein as expected, but did not react with any proteins from an E. coli lysate that was prepared from cells carrying vector alone (Fig. 17, lane E). However, instead of the IgE pool recognizing a 68 kD protein produced from clone P17, an unexpectedly small protein was identified (Fig. 17, lane C). On further analysis, we noted that by eliminating the first 93 bases (31 amino acids, 5% of Ara h I) of this clone we could produce full length Ara h I protein (68 kD) with numerous truncated products that migrated as smaller IgE reactive peptides (Fig. 17, lane D). The presence of truncated Ara h I products could be the result of inefficient translation of the amino terminal portion of this protein (23,24) caused by rare codons, numerous cysteine residues, or secondary structure of the mRNA.

Figure 18 shows eighteen immunoblot strips of recombinant Ara h I (Upper Panel) or native Ara h I (Lower Panel) that have been incubated with different patient sera. Ninety-four percent (17/18) of the patients that showed IgE binding to the native allergen also showed some level of binding to the recombinant Ara h I protein. Of the 18 patient sera tested in this manner there were varying intensities of IgE binding to the recombinant and native allergen. In general, there was good agreement between the level of IgE binding of recombinant and native Ara h I for any individual patient. For example, patients who had high levels of IgE which bound native protein (Figure 18, Lower panel, lanes A-F) also showed high

immunoreactivity with recombinant Ara h I protein (Figure 18, Upper panel, lanes A-F). Patients who had low levels of IgE which bound native allergen (Figure 18, Lower panel, lanes L-R) showed low reactivity with the recombinant protein (Figure 4, Upper panel, lanes L-R). One peanut sensitive individual (lane K) who had serum specific IgE to native Ara h I had no detectable IgE which recognized the recombinant protein (Figure 18, Upper Panel, lane K). The differences we have noted between peanut hypersensitive patients could be due to the amount of peanut-specific IgE in individual patients, differences in affinity of patient-specific IgE for peanut, or that some patients recognize only certain peanut proteins.

**DISCUSSION**

Peanuts are one of the most allergenic foods (25). Sensitive individuals may experience symptoms ranging from urticaria to anaphylaxis (25). Multiple cases of fatal anaphylaxis have been reported (4). Peanut sensitivity appears early in life and often persists indefinitely. Because of the significance of the allergic reaction and the widening use of peanuts as protein extenders in processed foods, the risk to the peanut-sensitive individual is increasing.

Various studies over the last several years have examined the nature and location of the multiple allergens in peanuts (26). Taylor et al demonstrated that the allergenic portion of peanuts was in the protein portion of the cotyledon (27). Our laboratory recently identified two major allergens from peanut extracts, designated Ara h I (6) and Ara h II (13). Greater than 90% of our patients who were challenge positive to peanut had specific IgE to these proteins.

The Ara h I nucleotide sequences identified in this report have significant sequence homology with the vicilin family of seed storage proteins of other legumes (soybean, pea, common bean, etc.). The major seed storage proteins of legumes are globulins that are represented in most legumes by two different types of polypeptides, the nonglycosylated legumins and glycosylated vicilins. The genes for the glycosylated seed storage proteins of higher plants code for proteins that are classified by their size into small (50 kD) and large (70 kD) vicilins (28). A comparison of the vicilin amino acid sequences reveals considerable amino acid homology between the small and large vicilins in the carboxy terminal portion of

these molecules. The major difference between the large and small vicilin preproteins is the existence of an additional tract of amino acids at the amino terminal end of the large vicilins (29). The information generated in our laboratory demonstrating that the major peanut allergens are vicilin-like proteins may explain why patients with peanut hypersensitivity and peanut-specific IgE tend to have serum IgE to multiple other legume proteins. Since the vicilins of most major plants share significant sequence homology in their carboxy terminal portion, it is not surprising that serum specific IgE would tend to bind to several vicilin proteins from different sources. However, despite patients with legume hypersensitivity having IgE to multiple legume proteins (peanuts, soybeans, peas, etc.) they generally have clinical food hypersensitivity to only one food in the legume family. Because the amino terminal domains of the large glycosylated (vicilin) proteins share little or no homology, the immune response to this portion of the protein may be responsible for the severe and chronic hypersensitivity response characteristic of peanuts.

We have demonstrated that the cloned *Ara h I* gene is capable of producing a protein product in procaryotic cells that is recognized by serum IgE from a large proportion of individuals with documented peanut hypersensitivity. These results are significant in that they indicate that some of the allergenic epitopes responsible for this reaction are linear amino acid sequences that do not include a carbohydrate component. These findings may provide the basis for the improving diagnosis and therapy of persons with food

hypersensitivity.

Current diagnosis of food hypersensitivity relies on a significant clinical history plus evidence of specific IgE to the food allergen in question. The absence of specific IgE to a food means there is a greater than 95% probability that the ingestion of the food will not lead to clinical symptoms. However, the presence of specific IgE to a particular food has only at best a 50% positive predictive value when correlated with a positive food challenge (1). One explanation of this low predictive value is the current use of crude allergen mixtures. The utilization of recombinant allergens should make it possible to obtain diagnostics with optimal concentrations of each allergen or to develop panels of mixtures of large numbers of recombinant allergens and then test for individual components. The disadvantages of recombinant allergens are that the IgE binding capacity of some may not be that of the corresponding natural allergen and that the number of recombinant allergens to be produced for any one food may need to be quite large.

Another possible use for recombinant peanut allergens is in immunotherapy. Allergen immunotherapy is an effective therapeutic modality for patients with insect sting hypersensitivity when they have experienced significant systemic symptoms (30). Because allergen immunotherapy can down-regulate the specific IgE response and the cellular response to allergens, treatment of patients with peanut immunotherapy is now being studied as a possible option (31). Immunotherapy with specific recombinant allergen epitopes rather than the crude allergen mixture could prove to be a more

effective treatment modality. Another utilization of immunotherapy could be the modification of the molecular structure of the recombinant allergen in order to reduce the IgE binding capacity while retaining the T-cell reactivity or the production of specific T-cell epitopes designed for immunotherapy. The use of recombinant allergens in standard allergen immunotherapy would have several advantages over natural allergens, including better control of the batch to batch variability of the specific allergens and the assurance of the representation of minor allergens in standard amounts. Our finding that recombinant Ara h I is recognized by a large proportion of people with peanut hypersensitivity will allow these immunotherapeutic approaches to be rigorously tested.

In the last several years the primary structure of a number of important inhaled allergens have been defined by cDNA cloning, including the house dust mite Group I allergen *Der p I* (32), the Birch pollen allergen *Bet v I* (33), and one of the ragweed allergens *Amb a II* (34). Similar work with foods has identified the major allergen in shrimp as a 34 kD heat-stable protein that has greater than 85% homology with tropomyosin for *Drosophila melanogaster* (35). Additionally, two different cDNA clones have been isolated in maize that share significant homology to several flower-expressed gene products, including short ragweed (36). Recent work by Valenta et al. (37,38) has shown that plant profilins are prominent allergens that can be isolated from pollens of birch, grass, and weeds. There has now been isolated a wheat profilin by cDNA cloning that appears to be a major food allergen (39).



The information we have gathered about the peanut Ara h I allergen and the recent identification of other recombinant food allergens should allow our understanding of the pathophysiologic and immunologic mechanisms involved in food hypersensitivity reactions to move forward. Future studies with the recombinant peanut allergens will allow a better understanding of the relevant allergens in peanuts, the human immune response involved in this hypersensitivity reaction, and the possible diagnostic and therapeutic capabilities of recombinant food allergens.

TABLE 14

## Amino Acid Sequence of Ara h I Peptides

<u>Peptide</u>	<u>Amino Acid Sequence</u>
I	I-F-L-A-G-D-K-D-N-V-I-D-Q-I-E-K
II	K-G-S-E-E-E-G-D-I-T-N-P-I-N-L-R
III	N-N-P-F-Y-F-P-S-R-R

TABLE 14. The amino acid sequence of three tryptic peptides derived from purified Ara h I protein was determined. The sequence is shown as the one letter amino acid code.

TABLE 15

## Homology of the Ara h I Gene to Plant Vicilins

	<u>Clone 41B</u>		<u>Clone P17</u>	
	bp overlap	% homology	bp overlap	% homology
<u>Broad Bean</u>	1,081	64.3	985	62.3
<u>Pea</u>	1,078	64.2	961	62.5
<u>Soybean</u>	323	65.9	815	61.2

TABLE 15. The Wisconsin DNA analysis software package was used to search for homology between the Ara h I nucleotide sequence and any DNA sequence contained in the data base. Significant homology was observed between Ara h I and the plant vicilins.

## Figure Legends

**FIGURE 15.** An *Ara h I* clone hybridizes to a 2.3 kb peanut mRNA. Peanut poly A+ RNA was isolated from *Arachis hypogaea* (Florunner) species and 10 micrograms were electrophoresed on denaturing formaldehyde agarose gels. Insert from 41B was purified, labeled with alpha-<sup>32</sup>P-dCTP, and used as a hybridization probe of a Northern blot of this gel. Sizes of known RNA species are expressed in kilobases along the right side of the figure.

**FIGURE 16.** Nucleotide sequence of an *Ara h I* cDNA clone. The nucleotide sequence of clone 41B is shown on the first line. The second line depicts clone P17 DNA sequence with dots (.) representing nucleotides that are the same, dashes (-) nucleotides that are missing, and A,C,G, or T nucleotides that differ between the two DNA sequences. The protein synthesis start (ATG) and stop (TGA) sites are underlined along with a consensus polyadenylation signal (AATAAA). Bold amino acid residues are those areas which correspond to the determined amino acid sequence of peptides I, II, and III of *Ara h I* (Table I). The numbers on the left of the figure indicate the nucleotide sequence, and those on the right correspond to the deduced amino acid sequence.

GenBank accession #L34402.

## FIGURE 17.

Serum IgE from a pool of peanut hypersensitive patients recognize recombinant Ara h I. Serum IgE from a pool of patients with reactivity to most peanut allergens was used to detect whole peanut extract (lane A), purified native Ara h I (lane B), recombinant Ara h I (lanes C and D), or *E. coli* extract (lane E). In preliminary experiments, we noted that full length clone P17 made small quantities of truncated recombinant protein (lane C). We found that by eliminating the first 93 bases of this clone we could produce large quantities of nearly full length Ara h I protein (lane D). The recombinant Ara h I (lane D; 68 kD) is larger than the native Ara h I (lane B; 65 kD) because the recombinant protein includes 37 amino acids of Beta galactosidase (See Material and Methods for details of the expression system). Note that the serum IgE pool does not recognize any proteins in the *E. coli* extract (lane E) and therefore the other bands in lane D are truncated versions of Ara h I. MW. - molecular weight standards expressed in kilodaltons.

## 25 FIGURE 18.

Serum IgE from individual patients with peanut hypersensitivity recognize recombinant and native Ara h I protein in an immunoblot assay. Upper Panel: *E. coli* XL1-Blue cells carrying

5

clone P172C were induced to express the recombinant Ara h I protein and lysates were prepared for immunoblot analysis. Each lane (A-R) represents a different patient with peanut hypersensitivity. Lower Panel: Lanes A-R, purified, native Ara h I protein was used in an immunoblot assay with serum IgE from the same individuals in the Upper Panel.

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PEANUT HYPERSENSITIVITY: IgE BINDING CHARACTERISTICS OF A  
RECOMBINANT ARA h I PROTEIN

Peanut allergy is a significant health problem because of the potential severity of the allergic reaction, the life-long nature of the allergic hypersensitivity, and the ubiquitous use of peanut products. Milk, eggs, and peanuts are three foods  
5 which cause over 80% of food hypersensitivity reactions in children (1,2). Unlike the food hypersensitivity reactions to milk and eggs, peanut hypersensitivity reactions usually persists into adulthood and last for a lifetime (3). Despite the prevalence of peanut hypersensitivity reactions and several  
10 fatalities annually, the identification of the clinically relevant antigens is incomplete and an understanding of the immunobiology of peanut hypersensitivity is very limited (4-6).

Recombinant methodology to clone allergens provides an efficient means of producing pure polypeptides which, in their  
15 native source, form complex mixtures and are often represented in only very small amounts (7). Several inhaled allergens have been cloned, including the allergens of house dust mites (8) and pollen grains (9,10), in comparison little work has been directed toward producing recombinant food allergens. Because  
20 of the prevalence and severity of peanut hypersensitivity reactions in both children and adults, coupled with the recent identification of two peanut allergens (Ara h I and Ara h II) that are involved in this process (11, 12), we set out to clone and characterize the Ara h I peanut allergen. Using serum IgE  
25 from peanut hypersensitive individuals, IgE reactive clones were isolated from a peanut cDNA expression library. Ara h I clones were then selected from this group of potential recombinant allergens by probing with a <sup>32</sup>P-labeled Ara h I PCR

clone constructed by amplifying peanut mRNA with an Ara h I oligonucleotide and oligo dT (Fig 19). After identification of a full-length Ara h I cDNA clone, the frequency of IgE binding by individual patients sera to the recombinant protein and purified, native Ara h I from whole peanut extracts was determined by immunoblot analysis. Of the 18 patients tested in this manner, 17 had IgE which recognized recombinant Ara h (Table 16). In general, there was good agreement between the level of IgE binding of recombinant and native Ara h I for each individual. For example, patients who had high levels of IgE binding to native allergen also showed high immunoreactivity with recombinant Ara h I protein. Patients who had low levels of IgE binding to native allergen showed low reactivity with the recombinant protein. Only one peanut sensitive individual who had serum IgE specific to native Ara h I had no detectable IgE which recognized the recombinant protein.

Since it appeared that the recombinant Ara h I protein bound IgE with the same degree/intensity as native allergen, we set out to map the major IgE binding domain(s) on the recombinant molecule. Exo III digestion from the 5' or 3' end of the full length Ara h I cDNA clone was used to produce shortened clones whose protein products could then be tested for IgE binding by immunoblot analysis (Fig 20).

The pluses (+) on the right side of this figure indicate the extent of IgE binding to the protein product of each construct. All constructs bound IgE until they were reduced to the extreme carboxyl terminal (5' Exo III) or amino terminal (3' Exo III) end of the molecule. These results indicate that there are multiple IgE epitopes on the Ara h I allergen. These

results are significant in that they indicate the utility of using recombinant peanut allergens for studying peanut hypersensitivity.

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TABLE 16

Comparison of Serum IgE Binding to Native and Recombinant Ara h I Protein

	Native	Recombinant
<u>Patient</u>	<u>Ara h I</u>	<u>Ara h I</u>
1	+++	+++
2	+++	+++
3	+++	+++
4	+++	+++
5	+++	+++
6	++	+++
7	+++	+++
8	++	++
9	++	++
10	+	+
11	+	-
12	+	+
13	+	+
14	+	+
15	+	+
16	+	+
17	+	+
18	+	+
19	-	-

TABLE 16. Purified Ara h I from whole peanut extracts or recombinant Ara h I protein was electrophoresed on denaturing polyacrylamide gels, blotted to nitrocellulose, and then probed with serum IgE from patients with peanut hypersensitivity (A-R) or serum IgE from an individual who is not peanut allergic (S). Patients were scored for the presence (+) or absence (-) of serum IgE to recombinant or native Ara h I.

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**FIGURE 19.** Strategy for isolation of Ara h I cDNA clones that produce IgE recognized proteins. Using Serum IgE from peanut hypersensitive individuals, IgE reactive clones were isolated from a peanut cDNA expression library as described by Burks et al. (13). Ara h I was then selected from this group of potential recombinant allergens by probing with a <sup>32</sup>P labeled Ara h I PCR clone.

**FIGURE 20.** EXO III deletions of the intact Ara h I cDNA clone indicate multiple IgE binding domains. Exo III digestion from the 5' or 3' end of the full length Ara h I cDNA clone was used to produce shortened clones whose protein products could then be tested for IgE binding by immunoblot analysis. The pluses (+) on the right side of this figure indicate the extent of IgE binding to the protein product of each construct. All constructs bound IgE until they were reduced to the extreme carboxyl terminal (5' Exo III) or amino terminal (3' Exo III) end of the molecule. These results indicate that there are multiple IgE epitopes on the Ara h I allergen.

THE IDENTIFICATION OF A FAMILY OF VICILIN-LIKE GENES ENCODING  
ALLERGENS RESPONSIBLE FOR PEANUT HYPERSENSITIVITY

Peanut allergy is a significant health problem because of the potential severity of the allergenic reaction and the chronicity of the allergic sensitivity. Two major peanut allergens, Ara h I and Ara h II, have been previously isolated and characterized. The gene encoding the Ara h I allergen has been cloned, sequenced, and found to have a high degree of homology with plant vicilin seed storage proteins. DNA hybridization analysis using <sup>32</sup>P. labeled Ara h I insert as a probe of a peanut cDNA library identified numerous clones with enough sequence similarity to cross-hybridize with this allergen. DNA sequence analysis of these clones revealed that there are at least two classes of genes encoding Ara h I-like proteins. Northern blot analysis of peanut poly A-RNA using representative clones from the two Ara h I classes as probes showed that they recognized the same size (2.3 kb) mRNA. In addition, each of the Ara h I like clones produces a recombinant peanut protein that is significantly bound by serum IgE from patients with peanut hypersensitivity. These results indicate that a family of vicilin-like genes in peanut are responsible for producing IgE binding proteins. The identification of this family of vicilin-like proteins as allergens may explain in part the reason that patients with peanut hypersensitivity produce IgE to multiple legumes containing similar vicilin proteins.

**SERUM IgE ANTIBODIES FROM WHEAT-ALLERGIC PATIENTS BIND A  
50 kD WHEAT PROTEIN**

Wheat is a major cause of food hypersensitivity, but information concerning specific wheat allergens is limited. The focus of this study was to isolate and characterize the clinically relevant allergens in wheat protein. Whole wheat  
5 extracts were prepared (1:10 w/y in PBS). The extracts (1 mg/ml) were separated with 10% SDS-PAGE and 10 Coomassie-stained protein bands (range: 16-65 kD) were obtained. The crude wheat extract was separated with a stepwise salt gradient (0-1.5 M NaCl) on a Mono-Q/FPLC anion exchange column resulting in two  
10 major protein peaks. SDS-PAGE (10%) analysis of Peak I revealed protein bands ranging from 16-40 kD, while Peak II contained wheat proteins greater than 45 kD. A 50 kD protein band was isolated from Peak II using 8% preparative cell-SDS-PAGE. An ELISA was designed to screen for serum-specific IgE  
15 antibodies to the isolated 50 kD wheat protein band. Seven wheat-allergic patients (ages: 1-17 yr. median 2 yr.) confirmed by prick skin tests, blinded challenges and/or convincing histories of anaphylaxis after wheat ingestion were studied. Sera from 3 patients without food allergy served as controls.  
20 Four of the 7 patient sera had significant IgE binding to the 50 kD wheat protein in the ELISA when compared to a negative control (range: 160-1200%, median 365%). IgE immunoblotting studies revealed that serum-specific IgE antibodies from all the wheat-allergic patients bound to this 50 kD protein. No  
25 binding was demonstrated with normal control sera. These studies demonstrate that serum IgE antibodies from wheat-allergic, pediatric patients binds a 50 kD protein from crude wheat extracts. Further characterization of this protein is

needed to delineate its significance in the pathogenesis of wheat hypersensitivity.

**Ara h I, A MAJOR ALLERGEN INVOLVED IN PEANUT  
HYPERSENSITIVITY, HAS MULTIPLE IGE BINDING DOMAINS**

Peanuts are one of the most allergenic foods. Peanut-allergic individuals may experience symptoms ranging from uricaria to anaphylaxis. Ara h I, a vicilin-like protein derived from the cotyledon, is a major peanut allergen involved in peanut hypersensitivity reactions. The gene encoding the Ara h I protein has been previously cloned and characterized. This gene has been used to produce recombinant Ara h I protein that retains IgE binding characteristics similar to the native protein. To understand the role of this allergen in causing IgE mediated disease, the IgE binding epitope(s) on the protein must be identified. To begin this process the Ara h I gene was digested with Eno III for varying lengths of time to produce a sub-library of clones with progressively shorter inserts. Clones produced in this manner were sequenced around the deletion point in order to ensure that the shortened, re-ligated clones were in frame and would produce the appropriate peanut peptide. These clones were then expressed in E. coli and their protein products tested for IgE binding by immunoblot analysis. All of the peptides produced by the shortened clones retained some level of IgE binding indicating that there are multiple Ara h I epitopes involved in peanut hypersensitivity. We are currently in the process of mapping the exact location of these epitopes within the Ara h I allergen.

PRODUCTION OF MURINE MONOCLONAL (mAb) ANTIBODIES TO ARA h I,  
A 63.5 kD ALLERGEN IN PEANUTS

Our previous study has identified a 63.5 kD allergen, Ara h I from peanuts, utilizing the serum of patients with atopic dermatitis and positive double-blind, placebo-controlled food challenges to peanut. This allergen isolated from crude  
5 extracts of Florunner peanuts was used as an immunogen to produce mAbs. Spleen cells from hyperimmunized BALB/c mice were fused with mouse myeloma cells using standard procedures. Hybridoma cell lines were screened for secretion of mAb by ELISA using insolubilized Ara h I. Culture supernatants from  
10 thirty subclones were further screened for Ara h I binding activity by SDS-PAGE/immunoblot analysis. Four clones were then selected for expansion and production of ascites in pristane-primed BALB/c mice. All four mAbs subtyped as lambda chain IgG<sub>1</sub>. Epitope specificity of the four mAb determined in  
15 a competitive binding ELISA of each clone against a biotinylated mAb and Ara h I revealed four different epitopes. In direct ELISA studies, these four mAbs recognized antigens in extracts of 2 other varieties of peanut tested, Spanish and Virginia, but did recognize antigens in soybean extracts.

20 Current work is underway to purify peanut allergens by mAb-affinity chromatography. These mAbs should allow for easier isolation of major allergens and provide reagents for the future standardization of peanut extracts.

IDENTIFICATION OF A SECOND MAJOR PEANUT ALLERGEN IN PATIENTS  
WITH ATOPIC DERMATITIS AND PEANUT HYPERSENSITIVITY

Peanuts are a common cause of food hypersensitivity reactions. We used the sera of 10 patients who had atopic dermatitis and a positive double-blind placebo-controlled food challenge to peanut to investigate the major allergens of peanut. Crude Florunner extracts were fractionated by anion exchange chromatography using a step gradient (limit buffer, 0.05M BisTris/1.5M NaCl). One hundred microliters of each 2.0 ml fraction was dot-blotted onto nitrocellulose paper and IgE-binding activity assessed using our serum pool to select allergen-containing fractions. A protein peak (OD 280) which eluted at 10% NaCl and demonstrated intense IgE-binding was further analyzed by two-dimensional SDS-PAGE/immunoblot analysis. The majority of this fraction is a protein which has a molecular weight of 17 kD and a pI of 5.2. Sequencing data from the N-terminus revealed the following initial 9 amino acids: G-Q-G-(W)-E-L-Q-G-D.

Based on IgE-binding activity and no known amino acid sequence identity to other allergens, we have designated this allergen Ara h II.

MONOCLONAL ANTIBODY ENZYME-LINKED IMMUNOSORBENT  
ASSAY (ELISA) FOR Ara h I, A MAJOR PEANUT ALLERGEN

Ara h I is a previously described major allergen in peanuts. Over 90% of our patients with documented food hypersensitivity reactions to peanut demonstrate specific -IgE to this allergen. IgG<sub>2</sub> products from 2 of 20 hybridoma cell  
5 lines produced against Ara h I were used to develop a 2-site monoclonal antibody ELISA. Monoclonal antibody 8D9 was used as the capture antibody and monoclonal antibody 8F10 was biotinylated to use as the 2nd antibody. A crude Florunner peanut extract was used as the standard. We chose 5 food  
10 products with peanuts on the label (including plain M&m's®), 5 food products without peanuts on the label, 3 commercial peanut oils and 2 commercial soy oils as extract source material. The amount of Ara h I in the peanut-labelled products varied from 1.4 µg/ml to 1777 µg/ml. No Ara h I allergen could be detected  
15 in peanut oil, soy oil or in any of the non-peanut food extracts. The specificity for the Ara h I ELISA should be useful for screening food products for this peanut allergen and correlating the amount of peanut allergen which might cause significant clinical reactions.



PRODUCTION OF MURINE MONOCLONAL (MaB) ANTIBODIES  
TO ARA h II, A 17 KD ALLERGEN IN PEANUTS

In a previous study we identified a 17 kD peanut allergen, Ara h II utilizing the serum of patients with atopic dermatitis and positive food challenges to peanuts. This allergen was used as an immunogen to produce mAbs. Spleen cells from 5 hyperimmunized BALB/c mice were fused with mouse myeloma cells using standard procedures. Hybridoma cell lines were screened for secretion of mAb by ELISA using insolubilized Ara h II. Culture supernatants from 40 subclones were further screened for Ara h II binding activity by SDS-PAGE/immunoblot analysis. 10 Four clones were then selected for expansion and production of ascites in pristane-primed BALB/c mice. All four mAbs subtyped as lambda chain IgG1. Epitope specificity of the four mAb was determined in competitive binding ELISAs. Using Ara h II as a solid phase antigen, serial dilution inhibition of each mAb 15 with a biotinylated mAb revealed at least 2 different epitopes. In a similar assay using our peanut-positive serum IgE pool, solid-phase Ara h II, and the four mAbs, we identified at least 2 different IgE-binding epitopes. In a direct ELISA, these 4 mAbs recognized antigens in extracts of 2 other varieties of 20 peanuts tested, but did not recognize antigens in soybean extracts. Production of these mAbs against Ara h II will allow definitive studies on the epitopes responsible for IgE binding.

CLONING OF THE ARA H II PEANUT ALLERGEN  
BY POLYMERASE CHAIN REACTION (PCR) AMPLIFICATION

Peanut allergy is a relatively common and sometimes fatal food allergy. Previous work has documented at least two major allergens in peanuts. The Ara h II allergen is composed of two proteins whose apparent molecular weights on SDS-PAGE are at 5 16.5 kD and 17.5 kD. These proteins were purified and N-terminal sequence analysis was used to determine the first 35 amino acids of each. Interestingly, their sequences were identical at 30 of the 345 amino acids determined for each protein. A set of oligonucleotide probes representing all of 10 the possible coding sequences for the first 7 common amino acids was then constructed. This set of oligonucleotide probes and a poly-dT sequence were used as primers in the PCR to amplify Ara h II sequences from first strand cDNA synthesized from peanut mRNA. Analysis of the products of this 15 amplification revealed two DNA bands at approximately 475 and 525 base pairs in length. These DNAs roughly correspond to the size required to encode the 16.5 kD and 17.5 kD Ara h II proteins, respectively. Northern analysis using total peanut RNA and alpha-32P-dCTP labelled PCR products as a probe 20 revealed that the amplified DNAs represented the nearly full length mRNAs. We are currently cloning and characterizing these DNAs. Once completed we will use these cloned sequences to synthesize the Ara h II proteins to allow the antigenic portions of these molecules to be mapped and studied.

**EPITOPE SPECIFICITY OF THE MAJOR PEANUT  
ALLERGEN, Ara h II**

Peanuts are considered one of the most allergenic foods.<sup>1</sup> Peanut allergy is a significant health problem because of the potential severity of the allergic reaction, the chronicity of the allergic sensitivity, and the ubiquity of peanut products. Individuals sensitive to peanuts may experience symptoms ranging from mild urticaria to severe, systemic anaphylaxis.<sup>1</sup> In food-induced, fatal anaphylaxis, peanuts are the food most commonly implicated in causing the reaction.<sup>2,3</sup> Sensitivity to peanuts often appears early in life, and unlike most other food allergies, tends to persist indefinitely.<sup>4</sup>

To elucidate the exact mechanism of IgE-mediated reactions, the identification and purification of the precise allergens are necessary. Significant information has accumulated in allergen characterization from a wide variety of sources, including pollens, dust mite, animal danders, and insects.<sup>5</sup> In comparison, allergen characterization for even the most common food allergens is much less defined. Despite the significant prevalence of peanut hypersensitivity reactions and several deaths annually, the identification of the clinically relevant antigens and an understanding of the immunobiology of peanut hypersensitivity is just beginning.

Monoclonal antibodies are being increasingly used to define and characterize the allergenic epitopes of many allergens. Multiple allergens including the dust mite allergen, *Der f I*,<sup>6</sup> and the grass pollen allergen, *Lol p I*,<sup>7</sup> have been studied by using monoclonal antibodies. Murine monoclonal antibodies to these allergens have been shown to be quite effective in defining their allergenic epitopes.

In this report we have investigated the epitope specificity of Ara h II,<sup>8</sup> a major peanut allergen, by using monoclonal antibodies as probes for mapping the possible antigenic determinants. We have produced and characterized a panel of monoclonal antibodies specific to Ara h II. The Ara h II monoclonal antibodies allowed us to define at least two antigenic sites on Ara h II. Inhibition assays were used to determine the IgE-binding sites on Ara h II.

#### **METHODS**

##### **10 Patients with positive peanut challenge responses**

Approval for this study was obtained from the Human Use Advisory Committee at the University of Arkansas for Medical Sciences. Twelve patients with atopic dermatitis and a positive immediate prick skin test response to peanut had either a positive response to double-blind placebo-controlled food challenge (DBPCFC) or a convincing history of peanut anaphylaxis (the allergic reaction was potentially life-threatening, that is with laryngeal edema, severe wheezing, and/or hypotension). Details of the challenge procedure and interpretation have been previously discussed.<sup>9</sup> Five milliliters of venous blood was drawn from each patient and allowed to clot, and the serum was collected. An equal volume of serum from each donor was mixed to prepare a peanut-specific IgE antibody pool.

##### **25 Crude peanut extract**

Three commercial lots of Southeastern Runners peanuts (*Arachis hypogaea*), medium grade, from the 1979 crop (North Carolina State University) were used in this study. The peanuts were stored in the freezer at -18°C until they were roasted. The three lots were combined in equal proportions and blended before defatting. The defatting process (defatted with

hexane after roasting for 13 to 16 minutes at 163°C to 177°C) was done in the laboratory of Dr. Clyde Young (North Carolina State University). The powdered crude peanut was extracted in 1 mol/L NaCl, 20 mmol/L sodium phosphate (pH 7.0)<sup>1</sup> and 8 mol/L urea for 4 hours at 4°C. The extract was clarified by centrifugation at 20,000 g for 60 minutes at 4°C. The total protein determination was done by the bicinchoninic acid method (Pierce Laboratories, Rockville, Ill.).

#### Monoclonal antibodies

10 Mouse hybridoma cell lines were prepared by standard selection after polyethylene glycol-mediated cell fusion was carried out as previously described.<sup>10</sup> Sp<sup>2</sup>/O-Ag<sup>14</sup> mouse/myeloma cells were fused with immune splenocytes from female BALB/c mice hyperimmunized with Ara h II. Hybridoma cell supernatants  
15 were screened by ELISA and Western blotting, and cell lines were cloned by limiting dilution. The antibodies secreted by the monoclonal hybridoma cell lines were isotyped according the directions provided (Screen Type; Boehringer Mannheim, Indianapolis, Ind.). Ascites fluid produced in BALB/c mice was  
20 purified with Protein G Superose, as outlined by the manufacturer (Pharmacia, Uppsala, Sweden). Purified monoclonal antibodies were used in ELISA and ELISA inhibition assays.

#### ELISA for IgE

A biotin-avidin ELISA was developed to quantify IgE anti-peanut protein antibodies with modifications from an assay  
25 previously described.<sup>11</sup> The upper 2 rows of a 96-well microtiter plate (Gibco, Santa Clara, Calif.) were coated with 100  $\mu$ l each of equal amounts (1  $\mu$ g/ml) of anti-human IgE monoclonal antibodies, 7.12 and 4.15 (kindly provided by Dr.  
30 Andrew Saxon). The remainder of the plate was coated with the

peanut protein at a concentration of 1  $\mu\text{g/ml}$  in coating buffer (0.1 mol/L sodium carbonate-bicarbonate buffer, pH 9.6). The plate was incubated at 37°C for 1 hour and then washed five times with rinse buffer (phosphate-buffered saline, pH 7.4, containing 0.05% Tween 20, Sigma Chemical Co., St. Louis, Mo.) immediately and between subsequent incubations. A secondary IgE reference standard was added to the upper 2 rows to generate a curve for IgE, ranging from 0.05 to 25 ng/ml.

The serum pool and patient serum samples were diluted (1:20 vol/vol) and dispensed into individual wells in the lower portion of the plate. After incubation for 1 hour at 37°C and washing, biotinylated, affinity-purified goat anti-human IgE (KPL, Gaithersburg, Md.) (1:1000 vol/vol bovine serum albumin) was added to all wells. Plates were incubated for 1 hour at 37°C and washed, and 100  $\mu\text{l}$  horseradish peroxidase-avidin conjugate (Vector Laboratories, Burlingame, Calif) was added for 5 minutes. After washing, the plates were developed by the addition of a citrate buffer containing 0-phenylenediamine (Sigma Chemical Co.). The reaction was stopped by the addition of 100  $\mu\text{l}$  2N hydrochloric acid to each well, and absorbance was read at 490 nm (Bio-Rad Microplate reader model 450; Bio-Rad Laboratories Diagnostic Group, Hercules, Calif.). The standard curve was plotted on a log-logit scale by means of simple linear regression analysis, and values for the pooled serum and individual samples were read from the curve.<sup>8,9</sup>

#### ELISA inhibition

An inhibition ELISA was developed to examine the site specificity of the monoclonal antibodies generated to Ara h II. One hundred microliters of Ara h II protein (1 mg/ml) was added to each well of a 96-well microtiter plate (Gibco) in coating

buffer (carbonate buffer, pH 9.6) for 1 hour at 37°C. Next, 100  $\mu$ l of differing concentrations (up to 1000-fold excess) of each of the monoclonal antibodies was added to each well for 1 hour at 37°C. After washing, a standard concentration of the  
5 biotinylated monoclonal antibody preparation was added for 1 hour at 37°C. The assay was developed by the addition of the avidin substrate as in the ELISA above.

A similar ELISA inhibition was performed with the peanut-positive serum IgE pool instead of the biotinylated monoclonal  
10 antibody to determine the ability of each monoclonal antibody to block specific IgE binding.

## RESULTS

### Hybridomas specific for Ara h II

Cell fusions between spleen cells obtained from female BALB/c mice immunized with Ara h II and the mouse myeloma cells resulted in a series of hybridomas specific for Ara h II. Seven monoclonal antibody-producing lines were chosen for  
5 further study. In preliminary studies all seven hybridoma-secreting cell lines had antibodies that bound Ara h II, as determined by ELISA and immunoblot analysis.<sup>12,13</sup> On the basis of different binding studies, four of the hybridomas were used for further analysis. As determined by isotype immunoglobulin-  
10 specific ELISA, all four hybridoma-secreting cell lines typed as IgG<sub>1</sub>.

### ELISA with monoclonal antibody as solid phase

Four monoclonal antibody preparations (4996D6, 4996C3, 5048B3, and 4996D5) were used as capture antibodies in an ELISA  
15 with Ara h II as the antigen. Serum from individual patients, who had positive challenge responses to peanut, was used to determine the amount of IgE binding to each peanut fraction

captured by the Ara h II-specific monoclonal antibody (Table 17). A reference peanut-positive serum pool was used as the control serum for 100% binding. Seven patients who had positive DBPCFC responses to peanut were chose. All seven  
5 patients had significant amounts of anti-peanut-specific IgE to the peanut antigen presented by each of the four monoclonal antibodies compared with the control sera (patient 8 without peanut sensitivity who had elevated serum IgE values, patient 9 without peanut sensitivity who had normal serum IgE values).  
10 Titration curves were performed to show that limited amounts of antigen binding were not responsible for similar antibody binding. There were no significant differences in the levels of anti-peanut-specific IgE antibody to the peanut antigens presented by each monoclonal antibody. Most patients had their  
15 highest value for IgE binding to the peanut antigen presented by either 4996D6 or 4996C3, whereas no patient had his or her highest percent of IgE binding to the peanut antigen presented by monoclonal antibody 4996D5.

**Food antigen specificity of monoclonal antibodies to Ara h II**

20 To determine whether the Ara h II monoclonal antibodies would bind to only peanut antigen, an ELISA was developed with the pooled peanut-specific IgE from patients who had positive DBPCFC responses to peanut. All four monoclonal antibodies that were fully characterized bound only peanut antigen (Table  
25 18). In the ELISA no binding to soy, lima beans, or ovalbumin occurred. When the normal serum pool was used in the ELISA, no peanut-specific IgE to either Ara h II or crude peanut could be detected.

In the United States, three varieties of peanuts are  
30 commonly consumed: Virginia, Spanish, and Runner. In an ELISA,



we attempted to determine whether there were differences in monoclonal antibody binding to the three varieties of peanuts. There was only a minor variation with the ability of the peanut-specific IgE to bind to the captured peanut antigen (data not shown).

#### **Site specificity of four monoclonal antibodies**

An inhibition ELISA was used to determine the site specificity of the four monoclonal antibodies to Ara h II (Table 19). As determined by ELISA inhibition analysis, there are at least two different epitomes on Ara h II, which could be recognized by the various monoclonal antibodies (epitope 1-4996C3, epitope 2-4996D6, 5048B3, 4996D5). Seven different monoclonal antibodies generated to Ara h I, a 63.5 kd peanut allergen,<sup>9</sup> were used to inhibit the binding of the four Ara h II monoclonal antibodies to the Ara h II protein. None of the Ara h I monoclonal antibodies inhibited any binding of the Ara h II monoclonal antibodies.

#### **Site specificity of peanut-specific human IgE**

Results of inhibition assays with monoclonal antibodies to inhibit IgE binding from the IgE pool (from patients with peanut hypersensitivity) to Ara h II are shown in Table 20. Monoclonal antibodies 4996C3 and 4996D5 inhibited the peanut-specific IgE up to approximately 25%. Monoclonal antibodies 4996D6 and 5048B3 did not inhibit peanut-specific IgE binding. These two inhibition sites correspond with the two different IgG epitopes recognized by the monoclonal antibodies in the inhibition experiments.

#### **DISCUSSION**

The route of allergen administration, dosage, frequency of exposure, and genetic factors all determine the type and

severity of an individual's allergic response.<sup>14</sup> To date, no distinct features, which would distinguish allergens as unique antigens, have been identified.<sup>14</sup> In contrast, only three foods in the United States (milk, eggs, and peanuts) account for approximately 80% of positive responses to food challenges in children.<sup>15</sup>

Although clinical sensitivity to most foods is typically lost as a patient ages, clinical sensitivity to peanut is rarely lost. For this reason, it is important to examine the peanut allergens to determine whether they have distinct features that would cause the persistence of clinical reactions.

Two major peanut allergens, Ara h I and Ara h II, have recently been identified and characterized.<sup>8,9</sup> Ara h I has two major bands as determined by sodium dodecylsulfate-polyacrylamide gel electrophoresis with a mean molecular weight of 63.5 kd and an isoelectric point of 4.55. Ara h II has a mean molecular weight of 17 kd and an isoelectric point of 5.2. Individual sequencing of Ara h I and Ara h II indicates that they are probably isoallergens.<sup>8</sup> Other peanut allergens have been identified including peanut 1<sup>16</sup> and concanavalin A-reactive glycoprotein.<sup>17</sup>

In this study four monoclonal antibodies to Ara h II were extensively characterized. All four monoclonal antibodies produced to Ara h II, when used as capture antibodies in an ELISA, presented antigens that bound IgE from patients with positive challenge responses to peanut. No significant differences were detected in the binding of IgE from any one patient to the allergen presented by the individual monoclonal antibodies. In separate ELISA experiments, the four monoclonal

antibodies generated to Ara h II did not bind to other legume allergens and did not bind to one variety of peanuts preferentially.

To determine the epitope site specificity of these  
5 monoclonal antibodies, inhibition ELISAs were done. At least two different and distinct IgG epitopes could be identified in experiments with the allergen, Ara h II. In related experiments done with pooled serum from patients with positive DBPCFC responses to peanut, two similar IgE epitopes were  
10 identified. The results of this study are comparable to those with monoclonal antibodies to Der f I<sup>18</sup> in which five nonoverlapping antigenic sites and three IgE-binding epitopes were identified. In our previous studies with Ara h I monoclonal antibodies,<sup>19</sup> four different antigenic sites were  
15 recognized, and three of these sites were IgE-binding epitopes.

In related experiments with other allergens, a variety of solid-phase inhibition assays have been used to block the polyclonal IgE response to the allergen being studied.<sup>6</sup> The interpretation of the level of inhibition that should be  
20 regarded as significant has varied from 15% to 80%.<sup>6</sup> The Ara h II monoclonal antibodies inhibited the polyclonal IgE response by up to 25%.

The characterization of these Ara h II monoclonal antibodies will allow future studies to better define the exact  
25 amino acid sequence that is responsible for IgE binding. Additionally, these monoclonal antibodies should make purification of the Ara h II allergen much simpler and more efficient. Immunoaffinity purification of allergens, such as that completed with the cockroach allergens<sup>6</sup> and with the Ara  
30 h I peanut allergen,<sup>19</sup> has produced a technique to purify

allergens from a heterogeneous crude source material.

Future studies on the antigenic and allergenic structure of allergens will likely use monoclonal antibody techniques, in addition to recombinant DNA technology. Monoclonal antibodies  
5 will be used to map these epitopes and to identify cDNA clones specific for the allergens. Together, recombinant DNA technology and monoclonal antibody production will be used to examine the role of specific T-cell epitopes in the induction and regulation of the allergenic response.<sup>20</sup>

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**ISOLATION, IDENTIFICATION, AND  
CHARACTERIZATION OF CLONES ENCODING ANTIGENS  
RESPONSIBLE FOR PEANUT HYPERSENSITIVITY**

Peanut allergy is a significant health problem because of the frequency, the potential severity, and the chronicity of the allergic sensitivity. Peanut hypersensitivity reactions often tend to be quite severe, sometimes resulting in episodes of fatal anaphylaxis [1,2]. Despite the significant prevalence of peanut hypersensitivity reactions and several fatalities annually, the identification of the clinically relevant antigens and an understanding of the immunobiology of peanut hypersensitivity are just beginning [3]. The identification and purification of allergens is essential for the immunological studies necessary to understand their role in stimulating IgE antibody formation. Because of the prevalence and severity of peanut hypersensitivity reactions in both children and adults, coupled with the recent identification of two major peanut allergens that are involved in this process [3,4], we set out to clone and characterize the Ara h I peanut allergen. Serum IgE from patients with documented peanut hypersensitivity reactions and a peanut cDNA expression library were used to identify clones that encode peanut allergens. One of the major peanut allergens, Ara h I, was selected from these clones using Ara h I-specific oligonucleotides and polymerase chain reaction technology. Using the oligonucleotide GA(TC)AA(AG)GA(TC)AA(TC)GTNAT(TCA)GA(TC)CA derived from amino acid sequence analysis of the Ara h I (63.5kD) peanut allergen as one primer and a 27-nucleotide-long oligo-dT stretch as the second primer, a portion of the mRNA that encodes this protein was amplified from peanut cDNA. To determine if this clone

(5Ala) represented the entire Ara h I, a <sup>22</sup>P-labeled insert from this clone was used as a hybridization probe of a Northern blot containing peanut poly A + RNA. This insert hybridized to a single-size mRNA of approximately 2.3 kb. The insert contained 1,360 bases not including the poly A tail. The sequence beginning at position 985 and extending through to position 1032 encodes an amino acid sequence identical to that determined from Ara h I peptide I. DNA sequence analysis of the cloned insert revealed that the Ara h I allergen has significant homology with the vicilin seed storage protein family found in most higher plants [5,6]. There were 64% homology over more than 1,000 bases when the clone 5Ala sequence was compared with the broad bean and pea vicilins. IgE immunoblot analysis was performed using serum IgE from patients with peanut hypersensitivity and Ara h I protein expressed from clone 5Ala in *Escherichia coli* XL1-Blue cells to address the question of how frequently recombinant Ara h I was recognized by these individuals. Figure 21 shows three representative immunoblot strips that have been incubated with different patient sera. Two of the patients showed strong IgE binding to the recombinant Ara h I protein while one patient had no detectable IgE binding to this protein. Of the 11 patient sera tested in this manner, 8 (73%) had IgE which recognized recombinant Ara h I (Table 21). We have demonstrated that the cloned Ara h I gene is capable of producing a protein product in prokaryotic cells that is recognized by serum IgE from a large number of individuals with documented peanut hypersensitivity. These results are significant in that they indicate that some of the allergenic



epitopes responsible for this reaction are linear amino acid sequences that do not include a carbohydrate component. These findings may provide the basis for improving diagnosis and therapy of persons with food hypersensitivity. With the  
5 production of the recombinant peanut protein it will now be possible to address the pathophysiologic and immunologic mechanisms regarding peanut hypersensitivity reactions specifically and food hypersensitivity in general.

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TABLE 17 Peanut-specific IgE to antigen presented by four monoclonal antibodies

Patient No.	Capture antibody			
	4996D6	4996C3	5048B3	4996D5
1	95%	80%	80%	91%
2	94%	66%	72%	90%
3	96%	114%	87%	96%
4	98%	116%	76%	96%
5	97%	74%	130%	107%
6	94%	63%	76%	86%
7	109%	123%	104%	116%
8	0%	0%	0%	0%
9	0%	0%	0%	0%

*Ara h* II monoclonal antibodies used as capture antibodies in ELISA with *Ara h* II as the antigen. Values are expressed as a percent of binding compared with challenge-positive peanut pool. Patients 1 to 7 had positive DBPCFC responses to peanut; patient 8 is the patient without peanut sensitivity with elevated serum IgE; patient 9 is the patient without peanut sensitivity with normal serum IgE.

TABLE 18 IgE-specific binding to legumes captured by *Ara h* II monoclonal antibodies

	Capture antibody			
	4996D6	4996C3	5048B3	4996D5
Pooled serum*				
<i>Ara h</i> II (17 kd)	0.451	0.565	0.235	0.381
Crude peanut	0.137	0.409	0.161	0.170
Soy	0.053	0.055	0.055	0.015
Lima beans	0.033	0.026	0.029	0.025
Ovalbumin	0.028	0.029	0.029	0.035
Normal serum				
<i>Ara h</i> II (17 kd)	0.024	0.031	0.038	0.033
Crude peanut	0.017	0.027	0.028	0.024

Values are expressed as optical density units.

\*Pooled serum is from patients with positive responses to peanut challenge.

TABLE 19 ELISA inhibition for four monoclonal antibodies to *Ara h* II

	Inhibitory antibody				
	4996C3	4996D6	5048B3	4996D5	Alt 1
Biotinylated mAb					
4996C3	99%	8%	6%	3%	1%
4996D6	0%	53%	31%	18%	9%
5048B3	30%	83%	100%	100%	3%
4996D5	1%	44%	56%	64%	8%

Site specificity of four *Ara h* II monoclonal antibodies as determined by ELISA inhibition analysis. Values are expressed as percent inhibition.

mAb, Monoclonal antibody.

TABLE 20 Individual anti-peanut-specific IgE binding to *Ara h* II

	Serum dilution					
	1:320	1:100	1:80	1:40	1:20	1:5
4996D6	0%	0%	0%	0%	3%	5%
4996C3	14%	10%	10%	12%	10%	24%
5048B3	0%	5%	5%	5%	7%	11%
4996D5	0%	10%	10%	22%	23%	25%

Site specificity of four *Ara h* II monoclonal antibodies inhibiting anti-peanut-specific IgE (serum pool from patients with peanut hypersensitivity) binding to *Ara h* II. Values are expressed as percent of anti-peanut-specific IgE binding to *Ara h* II without inhibiting monoclonal antibody.

TABLE 21 Recognition of *Ara h* I protein by patient serum IgE from patients with peanut hypersensitivity

Patient	Recombinant <i>Ara h</i> I	Native <i>Ara h</i> I
AC	+	+
BE	-	+
L	+	+
AS	-	+
KS	-	+
KF	+	+
CS	-	+
SM	-	+
TM	-	+
TH	-	+
JH	+	+

Recombinant or native *Ara h* I protein was electrophoresed on denaturing polyacrylamide gels, blotted to nitrocellulose, and then probed with serum IgE from patients with peanut hypersensitivity. Patients were scored for the presence (+) or absence (-) of serum IgE to recombinant or native *Ara h* I.

**Mapping of the B-cell Epitopes on Ara h I, a Legume Vicilin Protein and a Major Allergen in Peanut Hypersensitivity**  
**SUMMARY**

Peanut allergy is a significant health problem because of the potential severity of the allergic reaction and the difficulty in the accurate diagnosis of this disease. Serum IgE from patients with documented peanut hypersensitivity reactions and overlapping peptides were used to identify the major IgE binding epitopes on the major peanut allergen, Ara h I. At least twenty-three different linear IgE binding epitopes, located throughout the length of the Ara h I protein, were identified. Two of the peptides appeared to be immunodominant IgE binding epitopes in that they were recognized by serum from >90% of the patients tested. No other peptide was recognized by greater than 50% of the peanut sensitive population tested. Mutational analysis of the immunodominant epitopes revealed that single amino acid changes within these peptides had dramatic effects on IgE binding characteristics. With the identification of the IgE binding epitopes on the Ara h I protein and the determination of the amino acids within these epitopes important to immunoglobulin binding it will now be possible to address the pathophysiologic and immunologic mechanisms regarding peanut hypersensitivity reactions specifically and food hypersensitivity in general.

**INTRODUCTION**

Approximately 8% of children and 1-2% of adults have some type of food allergy (1). Peanuts, fish, tree nuts, and shellfish account for the majority of food hypersensitivity reactions in adults, while peanuts, milk, and eggs cause over 80% of food hypersensitivity reactions in children (2). Unlike

the food hypersensitivity reactions to milk and eggs, peanut hypersensitivity reactions usually persist into adulthood and last for a lifetime (3). In addition, hypersensitivity reactions to peanuts tend to be more severe than those to other food allergens. Allergic reactions to peanuts can produce symptoms ranging from urticaria to anaphylaxis in patients with peanut hypersensitivity. Several reports (4,5) have detailed fatal and near-fatal anaphylactic reactions occurring in adolescents and adults following the ingestion of peanuts or peanut products. Diagnosis of individuals with peanut hypersensitivity is often complicated by the presence of cross-reacting antibodies to other legumes (6). Currently, the only effective treatment for patients with peanut hypersensitivity is avoidance of any food products which contain the allergen. This is becoming more difficult due to the inclusion of peanuts and peanut products as protein extenders in many different foods.

Food hypersensitivity reactions occur shortly after contact of a specific allergen with its corresponding IgE antibodies which are bound to mast cells. Allergen-specific IgE when cross-linked by the respective allergen activates the mast cells to release histamine, heparin, and other mediators responsible for the clinical symptoms observed. Thus the IgE binding epitopes of the allergens play an important role in the disease process. Their characterization will provide a better understanding of the human immune response involved in food hypersensitivity reactions. If improved diagnostic and therapeutic capabilities are to be developed it is important to determine the primary structure and frequency of recognition of

any IgE binding epitopes contained within the allergen.

Various studies have shown that the most allergenic portion of the peanut is the protein fraction of the cotyledon (7). A major allergen found in the cotyledon is the peanut protein, Ara h I (8). This protein is recognized by >90% of peanut sensitive patients, thus establishing it as an important allergen (8). The majority of serum IgE recognition of the Ara h I allergen appears to be due to epitopes within this protein that are linear amino acid sequences that do not contain significant amounts of carbohydrate (8,9). The Ara h I allergen belongs to the vicilin family of seed storage proteins (9). Previous results have demonstrated similarity between the level of IgE binding to recombinant Ara h I protein and the native form of this allergen when individual patient serum was tested (9). These results indicated that the recombinant protein could be considered for use in both diagnostic and immunotherapeutic approaches to peanut hypersensitivity.

Because of the prevalence and severity of peanut hypersensitivity reactions in both children and adults, coupled with the difficult nature of diagnosing this food allergy, we set out to map and characterize the major IgE epitopes of the Ara h I allergen. In this communication we report the primary structure of the Ara h I IgE-binding epitopes recognized by peanut hypersensitive individuals. Two epitopes that bound peanut specific serum IgE from >90% of patients tested were identified. The amino acids important to peanut-specific IgE recognition of these epitopes were then determined for the purpose of using them in future diagnostic and immunotherapeutic approaches to this disease.

**MATERIALS AND METHODS**

**Patients.** Serum from fifteen patients with documented peanut hypersensitivity reactions (mean age, 25 yr) was used to identify the Ara h I IgE binding epitopes. Each of these individuals had a positive immediate prick skin test to peanut and either a positive double blind, placebo controlled, food challenge (DBPCFC) or a convincing history of peanut anaphylaxis (laryngeal edema, severe wheezing, and/or hypotension). One individual with elevated serum IgE levels (who did not have peanut specific IgE or peanut hypersensitivity) was used as a control in these studies. In some instances a serum pool was made by mixing equal aliquots of serum IgE from each of the 15 patients with peanut hypersensitivity. This pool was then used in immunoblot analysis experiments to determine the IgE binding characteristics of the population. At least five mls of venous blood were drawn from each patient and allowed to clot, and the serum collected. All studies were approved by the Human Use Advisory Committee at the University of Arkansas for Medical Sciences.

**Computer analysis of Ara h I sequence.** Sequence analysis of the Ara h I gene (9) and peptide sequences was done on the University of Arkansas for Medical Science's Vax computer using the Wisconsin DNA analysis software package. The predicted antigenic regions on the Ara h I protein are based on algorithms developed by Jameson and Wolf (10) that relates antigenicity to hydrophilicity, secondary structure, flexibility, and surface probability.

**Peptide synthesis.** Individual peptides were synthesized on a cellulose membrane containing free hydroxyl groups using Fmoc-amino acids according to the manufacturer's instructions (Genosys Biotechnologies, The Woodlands, TX). Synthesis of each peptide was started by esterification of an Fmoc-amino acid to the cellulose membrane. After washing, all residual amino functions on the sheet were blocked by acetylation to render it unreactive during the subsequent steps. Each additional Fmoc-amino acid is esterified to the previous one by this same process. After addition of the last amino acid in the peptide, the amino acid side chains were de-protected using a mixture of dichloromethane/trifluoroacetic acid/triisobutylsilane (1/1/0.05), followed by treatment with dichloromethane and washing with methanol. Membranes containing synthesized peptides were either probed immediately with serum IgE or stored at -20°C until needed.

**IgE binding assay.** Cellulose membranes containing synthesized peptides were incubated with the serum pool or individual serum from patients with peanut hypersensitivity diluted (1:5) in a solution containing TBS and 1% bovine serum albumin for at least 12 h at 4°C or 2 h at room temperature. Detection of the primary antibody was with <sup>125</sup>I-labeled anti-IgE antibody (Sanofi Pasteur Diagnostics, Chaska, MN).

## RESULTS

**There are Multiple IgE Binding Regions Throughout the Ara h I Protein.** The Ara h I protein sequence was analyzed using a computer program to model secondary structure and predict antigenicity based on the parameters of hydrophilicity, secondary structure, flexibility, and surface probability.

Eleven antigenic regions, each containing multiple antigenic sites, were predicted by this analysis along the entire length of the molecule (Fig. 22).

Seventy-seven overlapping peptides representing the entire length of the Ara h I protein were synthesized and probed with pooled serum to determine IgE binding to the predicted antigenic regions, or any other regions of the protein. Each peptide was 15 amino acids long and offset from the previous peptide by eight amino acids. These peptides were then probed with a pool of serum IgE from 15 patients with documented peanut hyper-sensitivity or with serum IgE from a control patient with no food allergy. Figure 23A shows 12 IgE binding regions along the entire length of the Ara h I protein recognized by this population of peanut hypersensitive patients. Serum IgE from the control patient did not recognize any of the synthesized peptides (data not shown). In general, there was good agreement between the predicted antigenic regions (Fig. 23B, boxed areas P1-P11) and those that were determined (Fig. 23B, shaded areas D1-D12) by actual IgE binding. However, there were two predicted antigenic regions (AA221-230; AA263-278) that were not recognized by serum IgE from peanut hypersensitive individuals. In addition, there were numerous IgE binding regions found in the Ara h I protein between amino acids 450-600 (Fig. 23A).

In order to determine the amino acid sequence of the IgE binding sites, small overlapping peptides spanning each of the larger IgE binding regions identified in Figure 23 were synthesized. By synthesizing smaller peptides (10 amino acids long) that were offset from each other by only two amino acids



it was possible to identify individual IgE binding epitopes within the larger IgE binding regions of the Ara h I molecule. Figure 24 shows a representative immunoblot and the respective amino acid sequence of the binding region D2-D3 (AA82-133).

5 Four epitopes (Fig. 24, numbers 4-7) were identified in this region. Similar blots were performed for the remaining IgE binding regions to identify the core amino acid sequences for each IgE epitope. Table 22 summarizes the 23 IgE epitopes (peptides 1-23) and their respective positions in the Ara h I  
10 molecule. The most common amino acids found were acidic (D,E) and basic (K,R) residues comprising 40% of all amino acids found in the epitopes. In addition, no obvious amino acid sequence motif was shared by the epitopes.

*Identification of Common Ara h I Epitopes Recognized by*  
15 *Serum IgE from Patients With Peanut Hypersensitivity.* Each set of twenty-three peptides was probed with serum IgE from 10 individuals to determine which of the twenty-three epitopes were recognized by serum IgE from patients with peanut hypersensitivity. Serum from five individuals randomly selected from  
20 the 15 patient serum pool and an additional five sera from peanut hypersensitive patients not represented in the serum pool were used to identify the common epitopes. Figure 25 shows the IgE binding results of the 10 immunoblot strips (A-J) containing these peptides incubated with individual patient  
25 sera. All of the patient sera tested (10/10) recognized multiple epitopes. The average number of epitopes recognized was 6/patient sera, ranging from one serum recognizing only 2 epitopes to another patient's serum recognizing 12 epitopes. The results are summarized in Table 23. Interestingly, epitope

17 was recognized by all patient sera tested (10/10) and epitope 4 was recognized by 90% (9/10) of patient sera tested. No other epitope was recognized by more than 50% of the patient sera tested.

5        *IgE binding Characteristics of Mutated Ara h I Epitopes.*

The amino acids essential to IgE binding in epitopes 4 and 17 were determined by synthesizing duplicate peptides with single amino acid changes at each position. The amino acids were changed to either an alanine or glycine residue because these  
10 amino acids have small, R groups. These peptides were then probed with pooled serum IgE from 15 patients with peanut hypersensitivity to determine if the change affected peanut-specific IgE binding. The results are shown in Figure 26. Clearly, a single amino acid substitution has dramatic effects  
15 on the IgE binding characteristics of that peptide. Replacement of any amino acid in the 91-96 region of epitope 4 resulted in almost complete loss of IgE binding to this epitope. In epitope 17, replacement of the tyrosine residue at position 500 or replacement of the glutamic acid residue at  
20 position 506 also resulted in dramatic decreases in IgE binding.

Significant sequence homology between epitopes 4 and 17 and seed storage proteins from other plants could explain the presence of cross-reacting antibodies to other legumes which  
25 complicates diagnosis. To assess the prevalence of the amino acid sequences of epitope 4 and 17 in other seed storage proteins, the complete Ara h 1 amino acid sequence was first used to select all plant proteins that shared sequence homology with the peanut vicilin. There were 93 entries selected on

this basis, representing amino acid sequences deposited in the protein data base from a variety of seed storage proteins. The amino acid sequence for epitope 17 was present in many of these proteins with sequence identity ranging from 20-60%.  
5 Interestingly, even in those proteins with only 20% identity the tyrosine at position 500 and the glutamic acid residue at position 506 were almost always conserved (Table 24). The amino acid sequence for epitope 4 was present in fewer of these proteins with sequence identity ranging from 20-30%. In every  
10 case, at least one of the amino acids at positions 91-96 were different from the peanut vicilin (Table 24).

#### DISCUSSION

The development of an IgE response to an allergen involves a series of interactions between T cells and B cells. B cells  
15 bearing appropriate antigen-specific receptors interact with proliferating allergen specific T-cells which leads to isotype switching and the generation of antigen-specific IgE. The antigen-specific IgE then binds to surface receptors of mast cells, basophils, macrophages, and other APCs enabling the  
20 immune system to respond to the next encounter with the specific antigen (B-cell epitope). Because antigen specific IgE plays such a critical role in the etiology of allergic disease, determination of allergen-specific, IgE binding epitopes is an important first step toward a better understanding of this  
25 complex disease process.

The vicilins are seed storage proteins found in most higher plants (11). A comparison of the vicilin amino acid sequences from different plant sources reveals that considerable sequence homology exists between the carboxyl two-

thirds of all these molecules. The major difference between the vicilins is found in the amino terminal end of these proteins where little sequence homology is detected (11). In sequence comparison studies (9) with other legumes, the peanut  
5 vicilin, Ara h I conforms to this general rule with the highest similarity being found in the carboxyl two-thirds of this molecule.

In the present study we have determined that there were multiple antigenic sites predicted for the Ara h I allergen. In  
10 general, as has been found with other allergens (12,13), there was good agreement between those residues predicted by computer analysis and B-cell epitopes determined by experimental analysis of overlapping peptides. This strong correlation between predicted and determined epitopes is probably due to  
15 the ability of the computer model to predict which regions of the molecule are exposed on the surface of the allergen, making them accessible to immunoglobulin interactions. There are at least 23 different IgE recognition sites on the major peanut allergen Ara h I. These sites are distributed throughout the  
20 protein. The identification of multiple epitopes on a single allergen is not novel. Allergens from cow milk (14), codfish (15), hazel, (16), soy (17) and shrimp (18) have all been shown to contain multiple IgE binding epitopes. The observation that  
25 reflects the polyclonal nature of the immune response to them and may be a necessary step in establishing a protein as an allergen.

The elucidation of the major IgE binding epitopes on Ara h I may also enable us to better understand the

immunopathogenic mechanisms involved in peanut hypersensitivity. Recent evidence suggests that there is a preferential variable heavy chain usage in IgE synthesis and a direct switching from IgM production to IgE synthesis (19).  
5 This would suggest that epitopes responsible for antigen-specific IgE antibody production may differ from those promoting antigen-specific IgG antibodies. Immuno-therapeutic approaches utilizing peptides representing IgG epitopes may be able to shift the balance of antigen-specific antibody  
10 production from IgE to IgG. We are currently identifying which of the IgE binding epitopes also bind IgG to determine if this would be a feasible strategy for patients with peanut hypersensitivity.

Two of the Ara h I peptides appear to be immunodominant  
15 IgE binding epitopes in that they are recognized by >90% of patient sera tested. Interestingly, epitope 17 which is located in the carboxyl end of the protein (AA 498-507), is in a region that shares significant sequence homology with vicilins from other legumes. The amino acids important to IgE  
20 binding also appear to be conserved in this region and may explain the possible cross-reacting antibodies to other legumes that can be found in sera of patients with a positive DBPCFC to peanuts. Epitope 4, located in the amino terminal portion (AA 89-98) of the protein, appears to be unique to this peanut  
25 vicilin and does not share any significant sequence homology with vicilins from other legumes. In addition, the amino acids important to IgE binding in this region are not conserved. These findings may enable us to develop more sensitive and specific diagnostic tools and lead to the design of novel

therapeutic agents to modify the allergic response to peanuts.

The only therapeutic option presently available for the prevention of a food hypersensitivity reaction is food avoidance. Unfortunately, for a ubiquitous food such as peanut, the possibility of an inadvertent ingestion is great. One therapeutic option used extensively for patients with allergic reactions to various aeroallergens and insect sting venoms is allergen desensitization immunotherapy. Allergen immunotherapy consists of injections of increasing amounts of allergens to which a patient has Type I immediate hypersensitivity (20,21). Allergens for immunotherapy are usually extracted from natural sources and represent mixtures of several different proteins, to many of which the patient is not allergic. These non-allergenic components could induce an IgE-response in hyposensitized patients (22) thus complicating their use as a therapeutic tool. One of the major improvements in allergen immunotherapy has been the use of standardized allergenic extracts which has been made possible by the use of recombinant allergens (23,24). While the absolute mechanism of immunotherapy is unknown, an increase in IgG or IgG4 antibody activity, a decrease in allergen-specific IgE levels, and a decrease in basophil activity have all been implicated (25-28) in mediating this response. Because allergen immunotherapy has been proven efficacious for treatment of some allergies, treatment with peanut immunotherapy is now being studied as a possible option (29). Our work showing the IgE binding epitopes of a major peanut allergen may allow for the use of immunodominant epitopes in this approach. One possible advantage of using peptides over using the whole allergen is

the reduced danger of anaphylaxis. The degranulation of mast cells requires the cross-linking of IgE antibodies bound to the high affinity FcεR I receptors (30). Peptides containing single IgE epitopes would be unable to bind to more than one  
5 IgE antibody and therefore unable to cross-link the bound IgE. We are currently exploring this possibility in *in vitro* and *in vivo* models.

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**FIGURE LEGENDS**

**FIGURE 22. There Are Multiple Predicted Antigenic Sites on the Ara h I Allergen.** The amino acid sequence of the Ara h I protein was analyzed for potential antigenic sites by the Jameson and Wolf (1988) algorithm. These predictions are based on a model that relates antigenicity to hydrophilicity, secondary structure, flexibility, and surface probability. There were 11 (1-11) predicted regions that contained multiple antigenic sites (octagons) along the entire length of the molecule. Amino acid residues (small numbers) are represented as alpha-helical (sinusoidal curve), Beta-sheet (saw tooth curve), and coil (flat sinusoidal curve) conformations. Beta turns are denoted by chain reversals.

**FIGURE 23. Multiple IgE Binding Regions Identified on the Ara h I Allergen.** Fig. 23A; Upper Panel: Epitope mapping was performed on the Ara h I allergen by synthesizing the entire protein in 15 amino acid long overlapping peptides that were offset from each other by 8 amino acids. These peptides were then probed with a pool of serum IgE from 15 patients with documented peanut hypersensitivity. The position of the peptides within the Ara h I protein are indicated on the left hand side of this panel. Lower Panel: The amino acid sequence of the Ara h I protein is shown in the lower panel. The numbered boxes correspond to the predicted antigenic regions (P1-P11). The hatched boxes (D1-D12) correspond to the IgE binding regions shown in Figure 2A.

**FIGURE 24. Core IgE Binding Epitopes Identified on the Ara h I Allergen.** Panel A: Detailed epitope mapping was performed on IgE binding regions identified in Fig. 23 by synthesizing 10

amino acid long peptides offset from each other by two amino acids. These peptides were then probed with a pool of serum IgE from 15 patients with documented peanut hypersensitivity. The data shown represents regions D2 and a portion of D3 encompassing amino acid residues 82-133. Numbers correspond to peptides as shown in Table 22. *Panel B:* The amino acid sequence (residues 82-133) of Ara h I that was tested in Panel A is shown. Shaded areas of boxes correspond to IgE binding peptides in Panel A.

10 **FIGURE 25. Commonly Recognized Ara h I Epitopes.** Core IgE binding epitopes were synthesized (10 amino acids long) and then probed individually with serum IgE from 10 patients with documented peanut hypersensitivity. The top panel represents where each of the Ara h I peptides (1-23) were placed on the  
15 membrane. Panels A-J show the peptides that bound serum IgE from patients with peanut hypersensitivity. The control panel was probed with sera from a patient with elevated IgE but who does not have peanut hypersensitivity.

**FIGURE 26. Amino Acids Involved in IgE Binding.** Epitope 4 and  
20 17 were synthesized with a glycine (G) or alanine (A) substituted for one of the amino acids in each of these peptides and then probed with a pool of serum IgE from 15 patients with documented peanut hypersensitivity. The letters across the top of each panel indicate the one letter amino acid  
25 code for the residue normally at that position and the amino acid that was substituted for it. The numbers indicate the position of each residue in the Ara h I protein.

Table 22. Ara h I IgE binding epitopes.

<u>PEPTIDE</u>	<u>AA SEQUENCE</u>	<u>Ara h I POSITION</u>
1	AKSSPYOKKT	25-34
2	QEPDDLKOKA	48-57
3	LEYDPRLVYD	65-74
4	GERTRGROPG	89-98
5	PGDYDDDRRO	97-105
6	PRREEGGRWG	107-116
7	REERE DWROP	123-132
8	EDWRRPSHOO	134-143
9	QPRKIRPEGR	143-152
10	TPGOFEDFFP	294-303
11	SYLOEFSRNT	311-320
12	FNAEFNEIRR	325-334
13	EQEERGORRW	344-353
14	DITNPINLRE	393-402
15	NNFGKLFEVK	409-418
16	GTGNLELVAV	461-470
17	RRYTARLKEG	498-507
18	ELHLLGFGIN	525-534
19	HRIFLAGDKD	539-548
20	IDOIEKOAKD	551-560
21	KDLAFPGSGE	559-568
22	KESHFVSARP	578-587
23	PEKESPEKED	597-606

The underlined portions of each peptide are the smallest IgE binding sequences as determined by the analysis as described in Fig. 24.

Table 23. IgE binding of core Ara h I epitopes by serum from peanut hypersensitive individuals.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Epitopes/ Patient
A				X	X									X			X	X		X				6
B	X	X		X	X										X		X							6
C	X	X	X	X	X	X			X		X	X	X	X	X							X		12
D	X			X	X								X		X		X							6
E			X	X			X	X	X	X	X						X			X	X	X		11
F		X		X					X								X							4
G	X	X	X										X			X	X							6
H		X		X													X							3
I				X			X	X									X	X	X	X			X	8
J			X				X	X		X							X			X		X		7
	4	5	3	9	4	1	0	3	4	2	1	3	3	1	3	1	10	2	1	4	1	3	1	Pts/epitope

Patients are indicated by letters (A-J) on the left hand side of the table. Ara h I peptides are indicated by number (1-23) across the top of the table. The number of epitopes recognized by each patient (epitopes/patient) is shown on the right hand side of the table. The number of patients that recognized each epitope (pts/epitope) is shown across the bottom of the table. An X indicates that a peptide bound IgE.

TABLE 24. Amino acid comparison of Ara h I epitopes 4 and 17 with similar regions in other seed storage proteins.

	<u>EPITOPE 4</u>		<u>EPITOPE 17</u>
<u>Ara h 1</u>	G <u>E</u> R <u>T</u> R <u>G</u> R <u>O</u> P <u>G</u>	<u>Ara h I</u>	R <u>R</u> <u>Y</u> T <u>A</u> R <u>L</u> K <u>E</u> G
<u>Soy</u>	F <u>P</u> R <u>P</u> Q <u>P</u> R <u>Q</u> E <u>E</u>	<u>Soy</u>	R <u>K</u> <u>Y</u> R <u>A</u> E <u>L</u> S <u>E</u> <u>Q</u>
<u>Cacao</u>	- <u>E</u> Q <u>C</u> E <u>Q</u> R <u>C</u> E <u>R</u>	<u>Jack bean</u>	R <u>R</u> <u>Y</u> A <u>A</u> T <u>L</u> S <u>E</u> <u>G</u>
<u>Pea</u>	E <u>E</u> H <u>E</u> E <u>E</u> K <u>Q</u> K <u>Y</u>	<u>Pea</u>	Q <u>R</u> <u>Y</u> E <u>A</u> R <u>L</u> A <u>D</u> <u>G</u>
<u>Maize</u>	W <u>E</u> D <u>D</u> N <u>H</u> H <u>H</u> H <u>H</u>	<u>Fava bean</u>	Q <u>N</u> <u>Y</u> K <u>A</u> K <u>L</u> S <u>P</u> <u>G</u>

The peptides representing Ara h I epitopes 4 and 17 were compared with similar regions from other seed storage proteins. The amino acids residues important to IgE binding are indicated as bold underlined letters. Those amino acids that are identical to the Ara h I sequence are underlined.

The Major Peanut Allergen Ara h 2 is a Seed Storage  
Protein With Multiple IgE-binding Epitopes

## INTRODUCTION

Immediate hypersensitivity reactions to foods occur in about 4% of children and 1% of adults and are mediated by the production of IgE antibodies to glycoproteins of very high abundance present in the food. Peanuts are a major cause of serious allergic reactions in both children and adults. The hypersensitivity to peanuts often starts in childhood and continues throughout life. This is in contrast to other childhood food allergies such as to milk and eggs which generally resolve spontaneously with age. In addition, peanut allergy is more likely to cause fatal anaphylaxis than any other food allergy. Currently, avoidance is the only effective means of dealing with food allergy, but the use of peanuts and peanut by-products as supplements in many different foods makes accidental consumption almost inevitable. Thus, the prevalence and chronic nature of peanut allergy, the potential severity of the allergic reaction, and the widespread use of peanuts in consumer foods necessitates improved methods for managing peanut hyper-sensitivity.

Food hypersensitivity reactions occur shortly after contact of a specific allergen with its corresponding IgE antibodies which are bound to mast cells. Cross-linking of the allergen-specific IgE by the respective allergen activates the mast cells to release histamine, heparin, and other mediators responsible for the clinical symptoms observed. Thus, the IgE binding epitopes of the allergens play an important role in the disease process. Their characterization will provide a better



understanding of the human immune response involved in food hypersensitivity reactions. If improved diagnostic and therapeutic capabilities are to be developed it is important to determine the primary structure of the major allergens, the IgE binding sites of these allergens, and the frequency of recognition of any IgE binding epitopes that are identified.

Various studies have shown that the most allergenic portion of the peanut is the protein fraction of the cotyledon. Two highly abundant glycoproteins found in the cotyledon are the peanut allergens, Ara h 1 and Ara h 2. These proteins are recognized by serum IgE from >90% of peanut sensitive patients, thus establishing them as important allergens. The majority of serum IgE recognition of the Ara h 1 and Ara h 2 allergens appear to be due to epitopes within these proteins that are linear amino acid sequences that do not contain significant amounts of carbohydrate. The gene encoding the Ara h 1 allergen has been cloned, sequenced, and identified as a seed storage protein belonging to the vicilin family of legume storage proteins.

The major peanut allergen, Ara h 2, has now been cloned and the nucleotide sequence determined. The derived amino acid sequence has been used to construct synthetic peptides and perform a detailed examination of the linear IgE binding epitopes of this protein.

**EXPERIMENTAL PROCEDURES**

*Patients.* Serum from 15 patients with documented peanut hypersensitivity (mean age, 25 yr) was used to identify peanut allergens. Each of these individuals had a positive immediate skin prick test to peanut and either a positive double-blind, placebo controlled, food challenge or a convincing history of peanut anaphylaxis (laryngeal edema, severe wheezing, and/or hypotension). Details of the challenge procedure and interpretation have been discussed previously. One individual with elevated serum IgE levels (who did not have peanut specific IgE or peanut hypersensitivity) was used as a control in these studies. At least five mls of venous blood were drawn from each patient and allowed to clot, and the serum was collected. All studies were approved by the Human Use Advisory Committee at the University of Arkansas for Medical Sciences.

*Isolation and amino acid sequence analysis of peanut allergen Ara h 2.* Ara h 2 was purified to near homogeneity from whole peanut extracts according to the methods of Burks et al. Purified Ara h 2 was electrophoresed on 12.5% acrylamide mini-gels (Bio-Rad. Hercules, CA) in Tris glycine buffer. The gels were stained with 0.1% Coomassie blue in 10% acetic acid, 50% methanol, and 40% water for 3 h with continuous shaking. Gel slices containing Ara h II were sent to the W.M. Keck Foundation (Biotechnology Resource Laboratory, Yale University, New Haven CT) for amino acid sequencing. Amino acid sequencing of intact Ara h 2 and tryptic peptides of this protein was performed on an Applied Biosystems sequencer with an on-line HPLC column that was eluted with increasing concentrations of acetonitrile.

**Peanut RNA isolation and northern (RNA) gels.** Three commercial lots from the 1979 crop of medium grade peanut species, *Arachis hypogaea* (Florunner) were obtained from North Carolina State University for this study. Total RNA was isolated from one gram of this material according to procedures described by Larsen. Poly A+ RNA was isolated using a purification kit supplied by collaborative Research (Bedford MA) according to manufacturer's instructions. Poly A+ RNA was subjected to electrophoresis in 1.2% formaldehyde agarose gels, transferred to nitrocellulose, and hybridized with <sup>32</sup>P-labeled probes according to the methods of Bannon et al.

**Computer analysis of Ara h II sequence.** Sequence analysis of the Ara h 2 gene was done on the University of Arkansas for Medical Science's Vax computer using the Wisconsin DNA analysis software package. The predicted Ara h 2 epitopes are based on a algorithms developed by Jameson and Wolf (1988) that relates antigenicity to hydrophilicity, secondary structure, flexibility, and surface probability.

**cDNA expression library construction and screening.** Peanut poly A+ RNA was used to synthesize double-stranded cDNA according to the methods of Watson and Jackson and Huynh et al. The cDNA was treated with EcoRI methylase and then ligated with EcoRI and XhoI linkers. The DNA was then ligated with EcoRI-XhoI cut, phosphatase treated Lambda ZAP XR phage arms (Stratagene, LaJolla, CA) and in vitro packaged. The library was 95% recombinants carrying insert sizes >400 bp. The library was screened using an IgE antibody pool consisting of an equal volume of serum from each patient with peanut hypersensitivity. Detection of primary antibody was with I<sup>125</sup>-

labeled anti-IgE antibody performed according to the manufacturer's instructions (Sanofi, Chaska, MN).

**PCR amplification of the Ara h 2 mRNA sequence.** Using the oligonucleotide CA(AG)CA(AG)TGGGA(AG)TT(AG)CA(AG)GG(N)GA(TC)AG  
5 derived from amino acid sequence analysis of the Ara h 2 peanut allergen as one primer and a 23 nucleotide long primer which hybridizes to the Bluescript vector, the cDNA that encodes Ara h 2 was amplified from the IgE positive clones. Reactions were carried out in a buffer containing 3 mM MgCl<sub>2</sub>, 500 mM KCl, 100  
10 mM Tris-HCl, pH 9.0. Each cycle of the polymerase chain reaction consisted of 1 min at 94° C, followed by 2 min at 42° C, and three minutes at 72° C. Thirty cycles were performed with both primers present in all cycles. From this reaction, a clone carrying an approximately 700 bp insert was identified.

15 **DNA sequencing and analysis.** DNA Sequencing was done according to the methods of Sanger et al. using either <sup>32</sup>P-end labeled oligonucleotide primers or on a automated ABI model 377 DNA sequencer using fluorescent tagged nucleotides. Most areas of the clone were sequenced at least twice and in some cases in  
20 both directions to ensure an accurate nucleotide sequence for the Ara h 2 gene.

**Peptide synthesis.** Individual peptides were synthesized on a derivatised cellulose membrane using Fmoc amino acid active esters according to the manufacturer's instructions  
25 (Genosys Biotechnologies, Woodlands, TX). Fmoc-amino acid derivatives were dissolved in 1-methyl-2-pyrrolidone and loaded on marked spots on the membrane. Coupling reactions were followed by acetylation with a solution of 4% (v/v) acetic anhydride in N,N-Dimethylformamide (DMF). After acetylation,

Fmoc groups were removed by incubation of the membrane in 20% (v/v) piperidine in DMF. The membrane was then stained with bromophenol blue to identify the location of the free amino groups. Cycles of coupling, blocking, and deprotection were repeated until the peptides of the desired length were synthesized. After addition of the last amino acid in the peptide, the amino acid side chains were deprotected using a solution containing a 1/1/0.5 mixture of dichloromethane/trifluoroacetic acid/triisobutylsilane. Membranes were either probed immediately or stored at -20°C until needed.

**IgE binding assay.** Cellulose membranes containing synthesized peptides were washed with Tris-buffered saline (TBS) and then incubated with blocking solution overnight at room temperature. After blocking, the membranes were incubated with serum from patients with peanut hypersensitivity diluted (1:5) in a solution containing TBS and 1% bovine serum albumin for at least 12 h at 4°C or 2 h at room temperature. Detection of the primary antibody was with <sup>125</sup>I-labeled anti-IgE antibody (Sanofi, Chaska, MN).

## RESULTS

**Isolation and partial amino acid sequence determination of the Ara h 2 protein.** The amino terminus of the purified Ara h 2 protein, or peptides resulting from trypsin digestion of this protein, were used for amino acid sequence determination. It was possible to determine the first 17 residues from peptide I and the first 13 residues from peptide II of the major peptide in each fraction. The amino acid sequence representing the amino terminus of the Ara h 2 protein (peptide I) and a tryptic

peptide fragment (peptide II) is noted in Table 25. These results confirm and extend previous amino acid sequence analysis of the Ara h 2 protein.

**Identification and characterization of clones that encode**

5 **peanut allergen Ara h 2.** RNA isolated from the peanut species, *Arachis hypogaea* (Florunner) was used to construct an expression library for screening with serum IgE from patients with peanut hypersensitivity. Numerous IgE binding clones were isolated from this library after screening  $10^6$  clones with  
10 serum IgE from a pool of patients with reactivity to most peanut allergens by Western blot analysis. Since the number of plaques reacting with serum IgE was too large to study all in detail we randomly selected a small portion of the positive clones for further analysis.

15 To identify which of the clones encoded the Ara h 2 allergen, a hybridization probe was constructed using an oligonucleotide developed from Ara h 2 amino acid sequence and PCR technology. The oligonucleotide sequence CA(AG)CA(AG)TGGGA (AG)TT(AG)CA(AG)GG(N)GA(TC)AG was derived from the amino  
20 terminus of the Ara h 2 peanut allergen (peptide I). Utilizing this oligonucleotide, an ~700-bp cDNA clone was identified. DNA sequence revealed that the selected clone carried a 741-base insert which included a 21-base poly A tail and a 240 base  
25 3' non-coding region. This insert contained a large open reading frame starting with an ACG codon and ending with a TAA stop codon at nucleotide position 480 (Fig. 27). The calculated size of the protein encoded by this open reading frame was ~17.5 kD, which is in good agreement with the molecular weight of Ara h 2 that has been determined experimentally. The amino

acid sequence that was determined from the amino terminus and a tryptic peptide from purified Ara h 2 (Table 25) were found in this clone. The additional coding region on the amino terminal end of this clone probably represents a signal peptide  
5 which would be cleaved from the mature Ara h 2 allergen.

To determine what size mRNA this clone identified, <sup>32</sup>P-labeled insert was used as a hybridization probe of a Northern blot containing peanut poly(A)+ RNA (Fig. 28). This insert hybridized to an ~0.7-kb mRNA. Since the size of the cloned  
10 insert and the size of the mRNA were in good agreement, coupled with the good agreement in both the calculated and determined size of the Ara h 2 protein and the identity of the determined amino acid sequence with that which was determined from the clone, we concluded that an Ara h 2 specific clone had been  
15 isolated.

***Peanut allergen Ara h 2 is a conglutin-like seed storage protein.*** A search of the GenBank database revealed significant amino acid sequence homology between the Ara h 2 protein and a class of seed storage proteins called conglutins. There was  
20 ~32% identity with the Ara h 2 protein and a delta conglutin from the lupin seed. These results indicate that the Ara h 2 allergen belongs to a conglutin-like family of seed storage proteins.

***Multiple IgE binding epitopes on the Ara h 2 protein.*** The  
25 Ara h 2 protein sequence was analyzed for potential antigenic epitopes by algorithms designed to determine which portion(s) of this protein could be responsible for antibody binding. There were four possible antigenic regions predicted by this analysis along the entire length of the molecule (Fig. 29).

Nineteen overlapping peptides representing the derived amino acid sequence of the Ara h 2 protein were synthesized to determine if the predicted antigenic regions, or any other regions, were recognized by serum IgE. Each peptide was 15 amino acids long and was offset from the previous peptide by eight amino acids. In this manner, the entire length of the Ara h 2 protein could be studied in large overlapping fragments. These peptides were then probed with a pool of serum from 12 patients with documented peanut hypersensitivity or serum from a control patient with no peanut hypersensitivity. Serum IgE from the control patient did not recognize any of the synthesized peptides (data not shown). In contrast, Figure 30 shows that there are five IgE binding regions along the entire length of the Ara h 2 protein that are recognized by this population of patients with peanut hypersensitivity. These IgE binding regions were amino acid residues 17-38, 41-62, 57-78, 113-134, and 129-154.

In order to determine the exact amino acid sequence of the IgE binding epitopes, small peptides (10 amino acids long offset by two amino acids) representing the larger IgE binding regions were synthesized. In this manner it was possible to identify individual IgE binding epitopes within the larger IgE binding regions of the Ara h 2 molecule (Fig. 31). The ten IgE binding epitopes that were identified in this manner are shown in Table 26. The size of the epitopes ranged from 6-10 amino acids in length. Three epitopes (aa17-26, aa23-32, aa29-38), which partially overlapped with each other, were found in the region of amino acid residues 17-38. Two epitopes (aa41-50, aa51-60) were found in region 41-62. Two epitopes (aa59-68,



aa67-76) were also found in region 57-78. Finally, three epitopes (aa117-126, aa129-138, aa145-154) were found in the overlappings regions represented by amino acid residues 113-134 and 129-154. Sixty-three percent of the amino acids represented in the epitopes were either polar or apolar uncharged residues. There was no obvious amino acid sequence motif that was shared by all the epitopes, with the exception that epitopes 6 and 7, which contained the sequence DPYSPS.

In an effort to determine which, if any, of the ten epitopes were recognized by the majority of patients with peanut hypersensitivity each set of ten peptides was probed individually with serum IgE from 10 different patients. Five patients were randomly selected from the pool of 12 patients used to identify the common epitopes and five patients were selected from outside this pool. An immunoblot strip containing these peptides was incubated with an individual's patient serum. The remaining patients were tested in the same manner and the intensity of IgE binding to each spot was determined as a function of that patient's total IgE binding to these ten epitopes (Fig. 32). All of the patient sera tested (10/10) recognized multiple epitopes (Table 27). The average number of epitopes recognized was about 4-5/patient ranging from two sera recognizing only 3 epitopes and one patients' sera recognizing as many as 7 epitopes. Interestingly, epitopes 3, 6, and 7 were recognized by all patients tested (10/10). No other epitope was recognized by more than 50% of the patients tested.

**DISCUSSION**

Peanuts are one of the most common food allergens in both children and adults. In addition, peanut hypersensitivity is less likely to resolve spontaneously and more likely to result in fatal anaphylaxis. Because of the significance of the allergic reaction and the widening use of peanuts as protein extenders in processed food, the risk to the peanut-sensitive individual is increasing.

Various studies over the last several years have examined the nature and location of the multiple allergens in peanuts. Taylor et al. demonstrated that the allergenic portion of peanuts was in the protein portion of the cotyledon. Our laboratory recently identified two major allergens from peanut extracts, designated Ara h 1 and Ara h 2. Greater than 90% of our patients who were challenge positive to peanut had specific IgE to these proteins. The Ara h 1 allergen has been identified as a seed storage protein with significant homology to the vicilins, a family of proteins commonly found in many higher plants. The Ara h 2 nucleotide sequence identified in this report has significant sequence homology with another class of seed storage proteins called conglutins. It is interesting to note that two of the major peanut allergens thus far identified are seed storage proteins that have significant sequence homology with proteins in other plants. This may explain the cross-reacting antibodies to other legumes that are found in the sera of patients that manifest clinical symptoms to only one member of the legume family.

In the present study we have determined that there were multiple antigenic sites predicted for the Ara h 2 allergen.

As has been found for another peanut allergen Ara h 1, and other allergens in general, there was good agreement between those residues predicted by computer analysis and B-cell epitopes determined by experimental analysis of overlapping  
5 peptides. This strong correlation between predicted and determined epitopes is probably due to the ability of the computer model to predict which regions of the molecule are accessible to immunoglobulin interactions. In fact, 3-D structural models of the Ara h 1 protein indicate that most of  
10 the peptides identified by computer modeling and experimental analysis as IgE binding epitopes are located on the surface of the molecule (unpublished observation).

There are at least 10 IgE recognition sites distributed throughout the major peanut allergen Ara h 2. The  
15 identification of multiple epitopes on a single allergen is not novel, there being reports of multiple IgE binding epitopes on allergens from many foods that cause immediate hypersensitivity reactions. The observation that most of these proteins have multiple IgE binding sites probably reflects the polyclonal  
20 nature of the immune response to them and may be a necessary step in establishing a protein as an allergen.

Recent evidence suggests that there is a preferential variable heavy chain usage in IgE synthesis and a direct switching from IgM production to IgE synthesis. This would  
25 suggest that epitopes responsible for antigen-specific IgE antibody production may differ from those promoting antigen-specific IgG antibodies and that there may be some structural similarity between peptides that elicit IgE antibody production. However, there was no obvious sequence motif that

was shared by the 23 different IgE binding epitopes of the peanut allergen Ara h 1. In the present study, two epitopes share a hexameric peptide (DPYSPS). It is significant to note that these peptides are recognized by serum IgE from all the  
5 peanut-hypersensitive patients tested in this study. In addition, serum IgE that recognize these peptides represent the majority of Ara h 2 specific IgE found in these patients. Whether there is any further structural similarity between the IgE binding epitopes of Ara h 2 remains to be determined.

10 The elucidation of the major IgE binding epitopes on Ara h 2 may enable us to design better therapeutic options for the prevention of anaphylaxis as a result of peanut hypersensitivity. The only therapeutic option presently available for the prevention of a food hypersensitivity  
15 reaction is food avoidance. Unfortunately, for a ubiquitous food such as peanut, the possibility of an inadvertent ingestion is great. One therapeutic option used extensively for patients with allergic reactions to various aeroallergens and insect sting venoms is allergen desensitization  
20 immunotherapy. Allergen immunotherapy consists of injections of increasing amounts of allergens to which a patient has Type I immediate hypersensitivity. While the absolute mechanism of immunotherapy is unknown, an increase in IgG or IgG<sub>4</sub> antibody activity, a decrease in allergen-specific IgE levels, and a  
25 decrease in basophil activity have all been implicated in mediating this response. Because allergen immunotherapy has been proven efficacious for treatment of some allergies, treatment with peanut immunotherapy is now being studied as a possible option. Our work showing the IgE binding epitopes of

a major peanut allergen may allow for the use of immunodominant epitopes in this approach.

Another potential immunotherapeutic approach that has recently attracted much attention is the use of DNA vaccines. In this approach a promoter region is placed 5' to the cDNA encoding the allergen and then introduced to the whole animal via intramuscular injection or intradermal application. Early work with a dust mite allergen, *Der p 1*, indicates that this approach can both prevent the development of an immunogenic response to a specific protein and dampen the response to a protein to which the animal has already been sensitized. We are currently exploring this possibility with the *Ara h 2* allergen.

**TABLE 25. AMINO ACID SEQUENCE OF Ara h 2 PEPTIDES**

<u>Peptide</u>	<u>Amino Acid Sequence</u>
I	X-Q-Q-W-E-L-Q-G-D-R-R-R-Q-S-Q-L-E-R
II	<u>A-N-L-R-P-C-E-Q-H-L-M-O-K</u>

The amino acid sequence of the amino terminus (I) and a tryptic peptide (II) derived from Ara h 2 protein was determined. The sequence is shown as the one letter amino acid code.

**TABLE 26. Ara h 2 IgE BINDING EPITOPES**

<u>PEPTIDE</u>	<u>AA SEQUENCE</u>	<u>Ara h 2 POSITION</u>
1	HASARQQWEL	17-26
2	QWELQGDRRC	23-32
3	DRRCQSQLER	29-38
4	LRPCEQHLMQ	41-50
5	KIQRDEDSYE	51-60
6	YERDPYSPSQ	59-68
7	SQDPYSPSPY	67-76
8	DRLQGRQQEQ	117-126
9	KRELRNLPQQ	129-138
10	QRCDLDVESG	145-154

**TABLE 27. IgE BINDING TO Ara h 2 EPITOPES**

	Epitopes/										
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>Pt</u>
A			X			X	X	X			4
B	X		X	X		X	X				5
C	X		X	X		X	X				5
D			X			X	X	X			4
E		X	X			X	X				4
F	X		X	X		X	X	X		X	7
G			X			X	X				3
H			X	X	X	X	X	X			6
I			X			X	X				3
<u>J</u>	<u>X</u>		<u>X</u>			<u>X</u>	<u>X</u>		<u>X</u>		<u>5</u>
Pts/	4	1	10	4	1	10	10	4	1	1	
Epitope											

Patients are indicated by letters (A-J) on the left hand side of the table. Ara h 2 peptides are indicated by number (1-10) across the top of the table. The number of epitopes recognized by each patient (epitopes/patient) is shown on the right hand side of the table. The number of patients that recognized each epitope is shown across the bottom of the table. An X indicates that a peptide bound IgE.

**FIGURE LEGENDS**

**FIGURE 27. Nucleotide Sequence of an Ara h II cDNA Clone.** The nucleotide sequence is shown on the first line. The second line is the derived amino acid sequence. Bold amino acid residues are those areas which correspond to the determined amino acid sequence of peptide I and II of Ara h II (Table 25). The numbers on the right of the figure indicate the nucleotide sequence.

**FIGURE 28. An Ara h II Clone Hybridizes to a 700 b Peanut mRNA.** Peanut poly A+ RNA was isolated from *Arachis hypogaea* (Florunner) species and 10 ug were electrophoresed on formaldehyde denaturing agarose gels. Insert from an Ara h II clone was purified, labeled with alpha-<sup>32</sup>P-dCTP, and used as a hybridization probe for Northern blot analysis of this gel. Sizes of known RNA species are expressed in kilobases along the right side of the figure.

**FIGURE 29. Multiple Predicted Antigenic Sites are Present in the Ara h 2 Allergen.** The amino acid sequence of the Ara h 2 protein was analyzed for potential antigenic epitopes by the Jameson and Wolf (1988) algorithm. These predictions are based on a model that relates antigenicity to hydrophilicity, secondary structure, flexibility, and surface probability. There were 4 predicted regions (1-4) that contained multiple antigenic sites (octagons) along the entire length of the molecule. Amino acid residues (small numbers) are represented as alpha-helical (sinusoidal curve), Beta-sheet (saw tooth curve), and coil (flat sinusoidal curve) conformations. Beta turns are denoted by chain reversals.



FIGURE 30. **Multiple IgE Binding Sites Identified in the Ara h 2 Allergen.** Epitope analysis was performed on the Ara h 2 allergen by synthesizing 15 amino acid long peptides, offset from each other by 8 amino acids for the entire protein molecule. These peptides, represented as spots 1-19, were then probed with a serum pool consisting of 15 patients with documented peanut hypersensitivity.

FIGURE 31. **Core IgE Binding Epitopes Identified on the Ara h 2 Allergen.** Epitope analysis was performed on the IgE binding sites identified in Fig. 30 by synthesizing 10 amino acid long peptides offset by two amino acids. These peptides were then probed with the 18 patient serum pool. Figure 31A is the peptide analysis of Ara h II amino acid residues 49-70. Figure 31B identifies the amino acid sequence of this region.

FIGURE 32.

Of the 10 patients five were selected at random from the 18 patient serum pool and five were patients with peanut hypersensitivity that were not included in the pool. Patient K represents a non-peanut sensitive (negative) control.

## Characterization of a Major Peanut Allergen:

### Mutational Analysis of the Ara h 1 IgE binding epitopes

Immediate hypersensitivity reactions to foods occur in about 6-8% of young children and 1% of adults. These reactions are mediated by the production of IgE antibodies to glycoproteins found in the food. Peanuts are a major cause of serious allergic reactions in both adults and children. Ara h 1, a major peanut allergen, has been extensively characterized and shown to contain 23 linear IgE binding epitopes. We set

out to determine the amino acids critical to their binding and to determine the location of these epitopes on the 3-D structure of the Ara h 1 molecule. To accomplish this, mutational analysis of each epitope was performed by synthesizing 10 amino acid long peptides with single amino acids changed at each position to alanine, followed by determination of the IgE binding capacity of each mutated epitope relative to wild-type. It was determined that changes in those amino acids located at positions, 4, 5, and 6 of the epitope have a greater influence than residues located on either end. In addition, the substitution of most apolar, charged residues resulted in the loss of IgE. More importantly, 21/23 epitopes could be mutated to non-IgE binding by a single amino acid substitution. The 3-D model of the Ara h 1 protein indicates that the majority of the IgE binding epitopes are located on the surface of the molecule. Currently, we are determining what effect the amino acid substitutions that lead to loss of IgE binding will have on the tertiary structure of the protein.

**Cloning, epitope mapping, and mutational analysis  
of Ara h 2, a major peanut allergen**

A major peanut allergen, Ara h 2, is recognized by serum IgE from 90% of patients with peanut hypersensitivity. Biochemical characterization of this allergen indicates that it is a glycoprotein of ~17.5 kDa. Using N-terminal amino acid sequence data from purified Ara h 2, oligonucleotide primers were synthesized and used to identify a clone (700 bp) from a peanut cDNA library. This clone was capable of encoding a 17.5 kDa protein with homology to the conglutin family of seed

storage proteins. The major linear IgE binding epitopes of this allergen were mapped using overlapping peptides synthesized on an activated cellulose membrane and pooled serum IgE from 15 peanut sensitive patients. Ten IgE binding epitopes were identified, distributed throughout the length of the Ara h 2 protein. The size of the epitopes ranged from 6-10 amino acids in length. Sixty-three percent of the amino acids represented in the epitopes were either polar or apolar uncharged residues. In an effort to determine which, if any, of the ten epitopes were recognized by the majority of patients with peanut hypersensitivity, each set of ten peptides was probed individually with serum IgE from 10 different patients. All of the patient sera tested recognized multiple epitopes. Three epitopes (aa29-38, aa59-68, and 67-76) were recognized by all patients tested. Mutational analysis of these immunodominant epitopes indicate that single amino acid changes result in loss of IgE binding. Both epitopes contained in region aa59-76 contained the amino acid sequence DPYSPS that appears to be necessary for IgE binding. These results may allow for the design of improved diagnostic and therapeutic approaches to peanut hypersensitivity.

**Ara h 3, a peanut allergen identified by using peanut sensitive patient sera adsorbed with soy proteins**

Peanuts and soybeans are members of the legume family and share several common antigenic fractions. Patients allergic to one of these foods have serum IgE antibodies which immunologically cross-react with other legumes. However, ingestion of other legumes generally does not induce an allergic reaction, suggesting that cross-reacting antibodies to

soy were removed from the sera of patients clinically allergic to peanuts. Adsorbed sera were then used to identify specific IgE binding to peanut immunoblots. Several peanut proteins ranging in size from 5 kDa to 49 kDa, were identified. A ~ 14 kDa protein identified in this manner was purified and prepared for amino acid sequence analysis. Amino terminal sequencing determined the first 23 amino acids of this protein. A search of the Genbank protein database with this peptide revealed that it had 61% identity with a soybean gene for glycinin subunit G3. A degenerate oligonucleotide primer was then designed from this data to use in conjunction with vector primers to amplify the clones that encode this protein from a peanut cDNA library. DNA sequencing of these clones also revealed ~ 70% homology with the soybean gene for glycinin subunit G3. These data indicate that while there is significant homology between the peanut and soybean glycinins there must be peanut-specific epitopes responsible for the binding of the soy-adsorbed serum IgE. Subsequent characterization of this allergen will include determination of the IgE binding epitopes and testing of the clinical relevance of this protein in peanut hypersensitivity. If this strategy is successful it will not only identify proteins that bind IgE but also those allergens and epitopes important in the disease process.

25      **MAPPING OF THE B-CELL EPITOPES ON Ara h I AND Ara h II  
         LEGUME STORAGE PROTEINS AND MAJOR ALLERGENS  
         INVOLVED IN PEANUT HYPERSENSITIVITY**

Approximately 8% of children and 1-2% of adults suffer from some form of food allergy. Reactions to peanuts are more likely than other food allergies to give rise to fatal or near

fatal anaphylaxis in sensitized patients. Ara h I (MW=63.5 kD) and Ara h II (MW=17 kD) are peanut proteins recognized by serum IgE from 90% of peanut sensitive patients, thus establishing them as clinically important allergens. Overlapping peptides representing the entire Ara h I and Ara h II molecules were constructed and IgE immunoblot analysis performed to determine which portions of these allergens were responsible for IgE binding. Utilizing a pool (n=15) of patients with peanut hypersensitivity, 23 IgE binding epitopes were identified on Ara h I and 6 epitopes were identified on Ara h II. Even though there were multiple epitopes identified on each allergen, two epitopes on Ara h I and one epitope on Ara h II were recognized by 90% of individual patient sera tested (n=10). The amino acids important for IgE binding in these immunodominant epitopes were determined by mutational analysis. The identification of the major Ara h I and Ara h II IgE binding epitopes may lead to improved diagnosis of peanut hypersensitivity and eventually to an improved therapeutic regimen for this disease. SUPPORTED IN PART BY THE NATIONAL INSTITUTE OF HEALTH, CLARISSA SOSIN ALLERGY RESEARCH FOUNDATION, AND ARKANSAS SCIENCE AND TECHNOLOGY AUTHORITY.

## INTRODUCTION

Approximately 1-2% of the USA population suffers from some form of food allergy. Peanuts, fish, tree nuts, and shell fish account for the majority of food hypersensitivity reactions in adults; while peanuts, milk, and eggs cause over 80% of food hypersensitivity reactions in children. Unlike the food hypersensitivity reactions to milk and eggs, peanut

hypersensitivity reactions usually persist into adulthood and last for a lifetime. In addition, hypersensitivity reactions to peanuts tend to be more severe than those to other food allergens, sometimes resulting in death. Several reports have  
5 detailed the fatal and near-fatal anaphylactic reactions occurring in adolescents and adults. Currently, avoidance is the only effective means of dealing with food allergy, but the use of peanuts and peanut by-products as supplements in many different foods makes accidental consumption almost inevitable.

10 Two major allergens involved in peanut hypersensitivity are the peanut proteins, Ara h I and Ara h II. These proteins are recognized by 90% of peanut positive patients, thus establishing them as clinically important allergens. Both proteins are seed storage proteins. Ara h I shares significant  
15 sequence homology with vicilin proteins from other plants while Ara h II is a conglutin like protein.

Food hypersensitivity reactions occur shortly after contact of a specific allergen with its corresponding IgE antibodies which are bound to mast cells. IgE, when complexed  
20 with antigen, will activate mast cells to release histamine, heparin, and other substances which are responsible for the clinical symptoms observed. Thus the IgE binding epitopes of the allergens play an important role in the disease process and their elucidation will lead to a better understanding of the  
25 human immune response involved in food hypersensitivity reactions and to improved diagnostic and therapeutic capabilities.

**Figures 22 and 29. Multiple Predicted Antigenic Sites  
in the Ara h I and Ara h II Allergens**

The amino acid sequences of the Ara h I and Ara h II proteins were analyzed for potential antigenic epitopes. These  
5 predictions are based on a model that relates antigenicity to hydrophilicity, secondary structure, flexibility, and surface probability. There were 11 (1-11) predicted regions that contained multiple antigenic sites (octagons) along the entire  
10 length of the Ara h I protein and 4 (1-4) predicted regions on the Ara h II protein. Amino acid residues (small numbers) are represented as alpha-helical (sinusoidal curve), Beta sheet (saw tooth curve), and coil (flat sinusoidal curve) conformations. Beta turns are denoted by chain reversals.

**Figures 23 and 30. Multiple IgE Binding Regions  
15 Identified in the Ara h I and Ara h II Allergens**

*Upper Panels:* Epitope mapping was performed on the Ara h I and Ara h II allergens by synthesizing each of these proteins in 15  
amino acid long overlapping peptides that were offset from each other by 8 amino acids. These peptides were then probed with  
20 a pool of serum IgE from 15 patients with documented peanut hypersensitivity. The position of the peptides within the Ara h I and Ara h II proteins are indicated on the left hand side of each panel.

*Lower Panels:* The amino acid sequences of the Ara h I and Ara  
25 h II proteins are shown in the lower panels. The numbered boxes correspond to the predicted antigenic regions (P1-P11; P1-P4). The hatched boxes (D1-D12; D1-4) correspond to the IgE binding regions shown in the upper panels.

**Figures 24 and 31. Core IgE Binding Epitopes  
Identified in the Ara h I and Ara h II Allergens**

Detailed epitope mapping was performed on IgE binding regions identified in Fig. 23 and 30 by synthesizing 10 amino acid long peptides offset from each other by two amino acids. These peptides were then probed with a pool of serum IgE from 15 patients with documented peanut hypersensitivity. The data shown represents regions D2 and a portion of D3 from Ara h I and region D2 from Ara h II. Numbers correspond to peptides as shown in Table 28. The amino acid sequences of Ara h I and Ara h II that were tested in the upper panels are shown. Shaded areas of boxes correspond to IgE binding peptides.

**Figures 25 and 32.  
Commonly Recognized Ara h I Epitopes**

Core IgE binding epitopes were synthesized (10 amino acids long) and then probed individually with serum IgE from 10 patients with documented peanut hypersensitivity. The top panels represent where each of the Ara h I peptides (1-23) and Ara h II peptides (1-6) were placed on the membrane. Panels A-J show the peptides that bound serum IgE from each patient. The control panels were probed with sera from a patient with elevated IgE but who does not have peanut hypersensitivity.

**Figures 26 and 33.  
Amino Acids Involved in IgE Binding**

Epitopes 4 and 17 from Ara h I and epitope 3 from Ara h II were synthesized with a glycine (G) or alanine (A) residue substituted for one of the amino acids in each of these peptides and then probed with a pool of serum IgE from 15 patients with documented peanut hypersensitivity. The letters across the top of each panel indicate the one letter amino acid code for the residue normally at that position and the amino



acid that was substituted for it. The numbers indicate the position of each residue in the Ara h I and Ara h II proteins.

#### SUMMARY

The major peanut allergens Ara h I and Ara h II have been  
5 cloned, sequenced, and identified as seed storage proteins.

B-cell epitopes of Ara h I and 6 B-cell epitopes of Ara h II were mapped using synthetic peptides probed with serum IgE from a population of peanut hypersensitive patients.

Epitope #4 (AA89-98) and #17 (AA498-507) of Ara h I and  
10 epitope #3 (AA59-66) of Ara h II were recognized by 90% of peanut hypersensitive patients tested.

Amino acids important to IgE binding of the immunodominant epitopes of Ara h I and Ara h II were determined.

Figure 34 is the same as Figure 16 with peptides I, II,  
15 III corresponding to the peptides in Table 14 highlighted by rectangular boxes.

Table 32 is a partial Ara h I Beta sequence (clone 5A1a).

Table 33 is an Ara h I Alpha sequence (clone p17).

Table 34 is the Ara h II sequence (clone Ara h II p38).

20 Table 35 is the Ara h I Beta sequence (clone p41b).

Table 36 is the Ara h II p38 translation of Ara h II p38.

TABLE 28

## Ara h I IgE Binding Epitopes

PEPTIDE	AA SEQUENCE*	Arah I POSITION
1	A K S S P Y Q K K T	25-34
2	Q E P D D L K Q K A	48-57
3	L E Y D P R L V Y D	65-74
4	G E R T R G R Q P G	89-98
5	P G D Y D D D R R Q	97-105
6	P R R E E G G R W G	107-116
7	R E R E E D W R Q P	123-132
8	E D W R R P S H Q Q	134-143
9	Q P R K I R P E G R	143-152
10	T P G Q F E D F F P	294-303
11	S Y L Q E F S R N T	311-320
12	F N A E F N E I R R	325-334
13	E Q E E R G Q R R W	344-353
14	D I T N P I N L R E	393-402
15	N N F G K L F E V K	409-418
16	G T G N L E L V A V	461-470
17	R R Y T A R L K E G	498-507
18	E L H L L G F G I N	525-534
19	H R I F L A G D K D	539-548
20	I D Q I E K Q A K D	551-560
21	K D L A F P G S G E	559-568
22	K E S H F V S A R P	578-587
23	P E K E S P E K E D	597-606

## Ara h II IgE Binding Epitopes

PEPTIDE	AA SEQUENCE*	Arah II POSITION
1	L L A A H A S A R Q	14-23
2	Q G D R R C Q S Q L	27-36
3	Y E R D P Y S P S Q	60-69
4	A G S S Q H Q E R C	81-90
5	C N E L N E F E N N	91-100
6	Q R C D L D V E S G	105-159

\* The underlined portions of each peptide are the smallest IgE binding sequences as determined by the analysis as described in FIG. 31.

TABLE 29

Ara h I Epitopes

IgE binding of core Ara h I epitopes by serum from peanut hypersensitive individuals.

																							Epitopes/ Patient	
Patients	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Patient
A					X	X								X				X	X		X			6
B	X	X			X	X										X		X						6
C	X	X	X	X	X	X	X			X			X	X		X		X					X	12
D	X				X	X							X			X		X						6
E				X	X			X	X	X	X	X						X			X	X	X	11
F			X		X						X						X							4
G	X	X	X										X				X							6
H		X			X												X							3
I				X				X	X								X	X	X	X			X	8
J				X				X	X			X					X			X		X		7
Patients/ Epitope	4	5	4	9	4	1	0	3	4	2	1	3	3	1	3	1	10	2	1	4	1	3	1	

Ara h II Epitopes

IgE binding of core Ara h II epitopes by serum from peanut hypersensitive individuals

Patients	1	2	3	4	5	6	Epitopes/ Patient
A			X				1
B			X		X		2
C			X				2
D			X			X	2
E			X	X	X		3
F			X				1
G			X				1
H			X	X	X		3
I			X			X	2
J			X		X	X	3
Patients/ Epitope	0	0	10	2	4	4	

Patients are indicated by letters (A-J) on the left hand side of the table. Ara h I & II peptides are indicated by number across the top of the table. The number of epitopes recognized by each patient (epitopes/patient) is shown on the right hand side of the table. The number of patients that recognized each epitope (patients/epitope) is shown across the bottom of the table. An X indicates that a peptide bound IgE.

Table 30  
IDENTIFICATION OF NATIVE AMINO ACID SEQUENCES IN THE DEDUCED  
AMINO ACID SEQUENCE OF CLONE ARA H 2 P38

THE FOLLOWING AMINO ACID SEQUENCE WAS TRANSLATED FROM THE ARA H 2  
P39 GENE (NUCLEOTIDE SEQUENCE) ISOLATED FROM OUR cDNA LIBRARY.

TRANSLATION of GENE: arah2p38

1 LTILVALALF LLAHASARQ N-terminal sequence QWELOGDRRC OSOLERANLR PCEOHLMOKI  
peptide 45

51 QREDSYERD peptide 37 PYSFSDPYS PSPYDRRGAG SSQHQRCCN ELNEFENNQR

101 CMCEALQQIM ENQSDRLQGR peptide 20 QQEQQEKREL RNLPQQCGLR APQRCDLDVE

151 SGGDRDY

Table 31

The following information was obtained by physicochemical measures and used  
to confirm the deduced amino acid sequence from clone Ara h 2 p 38.

17.5 kD N-TERMINAL SEQUENCE: gene sequence 19---48

1	2	3	4	5	6	7	8	9	10	11	12	13
GLY	GLN	GLN	TRP	GLU	LEU	GLN	GLY	ASP	ARG	ARG	ARG	GLN
	Q	Q	W	E	L	Q	G	D	R	R	R	Q
14	15	16	17	18	19	20	21	22	23	24	25	
SER	GLN	LEU	GLU	ARG	ALA	ASN	LEU	X	PRO	X	GLU	
S	Q	L	E	R	A	N	L	R	P	C	E	
26	27	28	29	30								
GLN	X	LEU	MET	X								
Q	H	K	M									

PEPTIDE 20: identified in gene sequence 121---128:

1	2	3	4	5	6	7	8
GLN	GLN	GLU	GLN	GLN	PHE	LYS	ARG
Q	Q	E	Q	Q	F	K	R

PEPTIDE 37: identified in gene sequence 60-76:

1	2	3	4	5	6	7	8	9	10	11	12	13
ASP	PRO	TYR	SER	PRO	SER	GLN	ASP	PRO	TYR	SER	PRO	SER
D	P	Y	S	P	S	Q	D	P	Y	S	P	S
14	15	16	17									
PRO	TYR	ASP	ARG									
P	Y	D	R									

PEPTIDE 45: identified in gene sequence 37-49:

1	2	3	4	5	6	7	8	9	10	11	12	13
ALA	ASN	LEU	ARG	PRO	CMC	GLU	GLN	HIS	LEU	MET	GLN	LYS
A	N	L	R	P	C	E	Q	H	L	M	Q	K

TABLE 32

LOCUS ARQARAHI 1340 bp ss-mRNA PLN  
 DEFINITION Arachis hypogea (clone 5 Ala) Ara h I mRNA, complete cds.  
 ACCESSION L34402  
 KEYWORDS  
 SOURCE Arachis hypogea (strain Florunner) seed cDNA to mRNA.  
 ORGANISM Arachis hypogea  
 Eukaryota; Plantae; Embryobionta; magnoliophyta; Magnoliopsida;  
 Rosidae; Fabales; Fabaceae.  
 REFERENCE 1 (bases 1 to 1340)  
 AUTHORS Burks, A.W., Cockrell, G., Stanley, J.S., Helm, R.M. and Bannon, G.A.  
 TITLE Recombinant peanut allergen Ara h I expression and IgE binding  
 in patients with peanut hypersensitivity  
 JOURNAL Unpublished (1994)  
 STANDARD full automatic  
 COMMENT NCBI gi: 508640  
 FEATURES Location/Qualifiers  
 source 1..1340  
 /organism="Arachis hypogea"  
 /strain="Florunner"  
 /dev\_stage="seed"  
 /sequenced\_mol="cDNA to mRNA"  
 CDS 231..1238  
 /gene="Ara h I"  
 /note="NCBI gi: 508641"  
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 SKAMVIVVVKGTGNLELVAVRKEQQQRGRREEEEDDEEEEGSNREVRRTARLKEG  
 DVFIMPAAHPVAINASSELHLLGFGINAENNRIFLAGDKDNVIDQIEKQAKDLAFPG  
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 N"  
 BASE COUNT 422 a 296 c 340 g 282 t  
 ORIGIN

Arqarahi Length: 1340 05:04 Type: N Check: 8329 ..

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101 CGTAGCAAAT GGCAATAACA GAAAGAGCTT TAATCTTGAC GAGGGCCATG
151 CACTCAGAAT CCCATCCGGT TTCATTTCTT ACATCTTGAA CCGCCATGAC
201 AACCAGAACC TCAGAGTAGC TAAAATCTCC ATGCCCCGTTA ACACACCCGG
251 CCAGTTTGAG GATTTCTTCC CGGCGAGCAG CCGAGACCAA TCATCCTACT
301 TGCAGGGCTT CAGCAGGAAT ACGTTGGAGG CCGCCTTCAA TGCGGAATTC
351 AATGAGATAC GGAGGGTGCT GTTAGAAGAG AATGCAGGAG GTGAGCAAGA
401 GGAGAGAGGG CAGAGGCGAT GGAGTACTCG GAGTAGTGAG AACAATGAAG
451 GAGTGATAGT CAAAGTGTC AAGGAGCACG TTGAAGAACT TACTAAGCAC
501 GCTAAATCCG TCTCAAAGAA AGGCTCCGAA GAAGAGGGAG ATATCACCAA
551 CCCAATCAAC TTGAGAGAAG GCGAGCCCGA TCTTTCTAAC AACTTTGGGA
601 AGTTATTTGA GGTGAAGCCA GACAAGAAGA ACCCCCAGCT TCAGGACCTG
651 GACATGATGC TCACCTGTGT AGAGATCAAA GAAGGAGCTT TGATGCTCCC
701 AACTTTCAAC TCAAAGGCCA TGGTTATCGT CGTCGTCAAC AAAGGAAGTG
751 GAAACCTTGA ACTCGTGGCT GTAAGAAAAG AGCAACAACA GAGGGGACGG
801 CGGGAAGAAG AGGAGGACGA AGACGAAGAA GAGGAGGGAA GTAACAGAGA
851 GGTGCGTAGG TACACAGCGA GGTGAAGGA AGGCGATGTG TTCATCATGC
901 CAGCAGCTCA TCCAGTAGCC ATCAACGCTT CCTCCGAAC CCATCTGCTT

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951 GGCTTCGGTA TCAACGCTGA AAACAACCAC AGAATCTTCC TTGCAGGTGA  
1001 TAAGGACAAT GTGATAGACC AGATAGAGAA GCAAGCGAAG GATTTAGCAT  
1051 TCCCTGGGTC GGGTGAACAA GTTGAGAAGC TCATCAAAAA CCAGAAGGAA  
1101 TCTCACTTTG TGAGTGCTCA ATCTCAATCT CAATCTCCGT CGTCTCCTGA  
1151 GAAAGAGTCT CCTGAGAAAAG AGGATCAAGA GGAGGAAAAC CAAGGAGGGA  
1201 AGGGTCCACT CCTTTCAATT TTGAAGGCTT TTAAGTGAAG ATGGAGGCAA  
1251 CTTGTTATGT ATCGATAATA AGATCACGCT TTTGTACTCT ACTATCCAAA  
1301 AACTTATCAA TAAATAAAAA CGTTTGTGCG TTGTTTCTCC

TABLE 33

LOCUS ARQARAH 1949 bp mRNA PLN  
 DEFINITION Arachis hypogea (clone P17) Ara h I mRNA, complete cds.  
 ACCESSION L38853  
 NID q620024  
 KEYWORDS peanut hypersensitivity.  
 SOURCE Arachis hypogea (strain Florunner) seed cDNA to mRNA.  
 ORGANISM Arachis hypogea  
 Eukaryota; Plantae; Embryobionta; magnoliophyta; Magnoliopsida;  
 Rosidae; Fabales; Fabaceae.  
 REFERENCE 1 (bases 1 to 1949)  
 AUTHORS Burks, A.W., Cockrell, G., Stanley, J.S., Helm, R.M. and Bannon, G.A.  
 TITLE Recombinant peanut allergen Ara h I expression and IgE binding  
 in patients with peanut hypersensitivity  
 JOURNAL Unpublished (1994)  
 COMMENT NCBI gi: 620024  
 FEATURES  
 source Location/Qualifiers  
 1. .1949  
 /organism="Arachis hypogea"  
 /strain="Florunner"  
 /dev\_stage="Seed"  
 /sequenced\_mol="cDNA to mRNA"  
 5'UTR 1. .2  
 CDS 3. .1847  
 /gene="Ara h I"  
 /note="NCBI gi: 620025"  
 /codon\_start=1  
 /db\_xref="PID:g620025"  
 /translation="MRGRVSPMLLLGILVLASVSATQAKSPYRK TENPCAQRCLQSC  
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 EETSRRNNPFYFSPRRFSTRYGNQNGRIRVLQRFQDQSKQFQNLQNHRIVQIEARPNTL  
 VLPKHADADNILVIQQGQATVTVANGNNRKS FNLDEGHALRIPSGFISYILNRHDNQN  
 LRVAKISMPVNTPGQFEDFFPASSRDQSSYLQGF SRNTLEAAFN AEFNEIRRVLLEEN  
 AGGEQEERGQRRRSTRSSDNEGVIKVSKEHVQELTKHAKSVSKKGSEEDITNPINL  
 RDGEPDLSNNFGRLFEVKPKDKNPQLQDLDMMLTCVEIKEGALMLPHFNSKAMVIVVV  
 NKG TGNLELVAVRKEQQQGRREQEWE EEEEEDEEEEGSNREVRRYTARLKEGDV FIMP  
 AAHPVAINASSELHLLGFGINAENNRIFLAGDKDNVIDQIEKQAKDLAFPGSGEQVE  
 KLIKQRESHFVSAR PQSQSPSSPEKEDQEEENQGGKGPLLSILKAFN"  
 3'UTR 1848. .1949  
 polyA\_site 1949  
 BASE COUNT 599 a 455c 517g 378t  
 ORIGIN

Arqarah Length: 1949 1996 16:44 Type: N Check: 6409 ..

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51 CTGGCTTCAG TTTCTGCAAC GCAGGCCAAG TCACCTTACC GGAAAACAGA
101 GAACCCCTGC GCCCAGAGGT GCCTCCAGAG TTGTCAACAG GAACCGGACG
151 ACTTGAAGCA AAAGGCATGC GAGTCTCGCT GCACCAAGCT CGAGTATGAT
201 CCTCGTTGTG TCTATGACAC TGGCGCCACC AACCAACGTC ACCCTCCAGG
251 GGAGCGGACA CGTGGCCGCC AACCCGGAGA CTACGATGAT GACCGCCGTC
301 AACCCCGAAG AGAGGAAGGA GGCCGATGGG GACCAGCTGA ACCGAGGGAG
351 CGTGAAAGAG AAGAAGACTG GAGACAACCA AGAGAAGATT GGAGGCGACC
401 AAGTCATCAG CAGCCACGGA AAATAAGGCC CGAAGGAAGA GAAGGAGAAC
451 AAGAGTGGGG AACACAGGT AGCGAGGTGA GGGAAGAAAC ATCACGGAAC
501 AACCTTTTCT ACTTCCCGTC AAGGCGGTTT AGCACCCGCT ACGGGAACCA
551 AAACGGTAGG ATCCGCGTCC TGCAGAGGTT TGACCAAAGG TCAAAGCAGT

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601	TTCAGAATCT	CCAGAATCAC	CGTATTGTGC	AGATCGAGGC	CAGACCTAAC
651	ACTCTTGTTT	TTCCCAAGCA	CGCTGATGCT	GATAACATCC	TTGTTATCCA
701	GCAAGGACAA	GCCACCGTGA	CCGTAGCAAA	TGGCAATAAC	AGAAAGAGCT
751	TTAATCTTGA	CGAGGGCCAT	GCACTCAGAA	TCCCATCCGG	TTTCATTTCC
801	TACATCTTGA	ATCGACATGA	CAACCAGAAC	CTCAGAGTAG	CTAAAATCTC
851	CATGCCCGTT	AACACGCCCG	GCCAGTTTGA	GGATTTCTTC	CCGGCGAGCA
901	GCCGAGACCA	ATCATCCTAC	TTGCAGGGAT	TCAGCAGGAA	TACTTTGGAG
951	GCCGCCTTCA	ATGCGGAATT	CAATGAGATA	CGGAGGGTGC	TGTTAGAAGA
1001	GAATGCAGGA	GGAGAGCAAG	AGGAGAGAGG	GCAGAGGCCA	CGGAGTACTC
1051	GGAGTAGTGA	TAATGAAGGA	GTGATAGTCA	AAGTGTCAAA	GGAGCACGTT
1101	CAAGAACTTA	CTAAGCACGC	TAAATCCGTC	TCAAAGAAAG	GCTCCGAAGA
1151	GGAAGATATC	ACCAACCCAA	TCAACTTGAG	AGATGGCGAG	CCCGATCTTT
1201	CTAACAACCT	TGGGAGGTTA	TTTGAGGTGA	AGCCAGACAA	GAAGAACCCC
1251	CAGCTTCAGG	ACCTGGACAT	GATGCTCACC	TGTGTAGAGA	TCAAAGAAGG
1301	AGCTTTGATG	CTCCACACT	TCAACTCAAA	GGCCATGGTC	ATCGTCGTCG
1351	TCAACAAAGG	AAC TGGAAC	CTTGAAC TCG	TAGCTGTAAG	AAAAGAGCAA
1401	CAACAGAGGG	GACGGCGGGA	ACAAGAGTGG	GAAGAAGAGG	AGGAAGATGA
1451	AGAAGAGGAG	GGAAGTAACA	GAGAGGTGCG	TAGGTACACA	GCGAGGTTGA
1501	AGGAAGGCGA	TGTGTTTCATC	ATGCCAGCAG	CTCATCCAGT	AGCCATCAAC
1551	GCTTCCTCCG	AAC TCCATCT	GCTTGGCTTC	GGTATCAACG	CTGAAAACAA
1601	CCACAGAATC	TTCTTTGCAG	GTGATAAGGA	CAATGTGATA	GACCAGATAG
1651	AGAAGCAAGC	GAAGGATTTA	GCAFTCCCTG	GTTCCGGTGA	ACAAGTTGAG
1701	AAGCTCATCA	AAAACCAGAG	GGAGTCTCAC	TTTGTGAGTG	CTCGTCCTCA
1751	ATCTCAATCT	CCGTCTGTCTC	CTGAAAAAGA	GGATCAAGAG	GAGGAAAACC
1801	AAGGAGGGAA	GGGTCCACTC	CTTTCAATTT	TGAAGGCTTT	TAACTGAGAA
1851	TGGAGGAAAC	TTGTTATGTA	TCCATAATAA	GATCACGCTT	TTGTAATCTA
1901	CTATCCAAAA	ACTTATCAAT	AAATAAAAAC	GTTTGTGCGT	TGTTTCTCC



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TABLE 34

LOCUS ARQALLII 717 bp DNA PLN  
 DEFINITION Arachis hypogea (clone Ara h II p38) allergen II gene, polyA signal.  
 ACCESSION L77197  
 NID g1236995  
 KEYWORDS allergen; conglutin; seed storage protein.  
 SOURCE Arachis hypogea (strain Florunner) (clone: Ara h II p38) DNA.  
 ORGANISM Arachis hypogea  
 Eukaryotae; mitochondrial eukaryotes; Viridiplantae;  
 Charophyta/Embryophyta group; Embryophyta; Magnoliophyta;  
 Magnoliopsida; Rutanae; Sapindales; Fabaceae; Papilionoideae;  
 Arachis.  
 REFERENCE 1 (bases 1 to 717)  
 AUTHORS Stanley, J.S.  
 TITLE The major peanut allergen Ara h II is a seed storage protein with multiple IgE-binding epitopes  
 JOURNAL Unpublished (1996)  
 FEATURES Location/Qualifiers  
 source 1..717  
 /organism="Arachis hypogea"  
 /strain="Florunner"  
 /clone="Ara h II p38"  
 polyA\_signal 562..567  
 BASE COUNT 217 a 152 c 184g 164 t  
 ORIGIN

Arqallii Length: 717 1996 14:32 Type: N Check: 3606 ..

```

1  GCTCACCATA CTAGTAGCCC TCGCCCTTTT CCTCCTCGCT GCCCAGCGCAT
51 CTGCGAGGCA GCAGTGGGAA CTCCAAGGAG ACAGAAGATG CCAGAGCCAG
101 CTCGAGAGGG CGAACCTGAG GCCCTGCGAG CAACATCTCA TGCAGAAGAT
151 CCAACGTGAC GAGGATTTCAT ATGAACGGGA CCCGTACAGC CCTAGTCAGG
201 ATCCGTACAG CCCTAGTCCA TATGATCGGA GAGGCGCTGG ATCCTCTCAG
251 CACCAAGAGA GGTGTTGCAA TGAGCTGAAC GAGTTTGAGA ACAACCAAAG
301 GTGCATGTGC GAGGCATTGC AACAGATCAT GGAGAACCAG AGCGATAGGT
351 TGCAGGGGAG GCAACAGGAG CAACAGTTCA AGAGGGAGCT CAGGAACTTG
401 CCTCAACAGT GCGGCCTTAG GGCACCACAG CGTTGCGACT TGGACGTCGA
451 AAGTGGCGGC AGAGACAGAT ACTAAACACC TATCTCAAAA AAAGAAAAGA
501 AAAGAAAAGA AAATAGCTTA TATATAAGCT ATTATCTATG GTTATGTTTA
551 GTTTTGGTAA TAATAAAGAT CATCACTATA TGAATGTGTT GATCGTGTTA
601 ACTAAGGCAA GCTTAGGTTA TATGAGCACC TTTAGAGTGC TTTTATGGCG
651 TTGTCTATGT TTTGTTGCTG CAGAGTTGTA ACCATCTTGA AATAATATAA
701 AAAGATCATG TTTTGTT

```

TABLE 35

LOCUS ARQARAHI 2032 bp mRNA PLN  
 DEFINITION Arachis hypogea (clone P41b) Ara h I mRNA, complete cds.  
 ACCESSION L34402  
 NID g602435  
 KEYWORDS allergen.  
 SOURCE Arachis hypogea (strain Florunner) seed cDNA to mRNA.  
 ORGANISM Arachis hypogea  
 Eukaryota; Plantae; Embryobionta; Magnoliophyta; Magnoliopsida;  
 Rosidae; Fabales; Fabaceae.  
 REFERENCE 1 (bases 1 to 2032)  
 AUTHORS Burks, A.W., Cockrell, G., Stanley, J.S., Helm, R.M. and Bannon, G.A.  
 TITLE Recombinant peanut allergen Ara h I expression and IgE binding  
 in patients with peanut hypersensitivity  
 JOURNAL Unpublished (1994)  
 STANDARD full automatic  
 COMMENT NCBI gi: 602435  
 FEATURES  
 source Location/Qualifiers  
 1. .2032  
 /organism="Arachis hypogea"  
 /strain="Florunner"  
 /dev\_stage="seed"  
 /sequenced\_mol="cDNA to mRNA"  
 /clone="P41b"  
 5' UTR  
 CDS  
 <1. .49  
 50. .1930  
 /gene="Ara h I"  
 /note="NCBI gi: 602436"  
 /codon\_start=1  
 /db\_ref="PID:g602436"  
 /translation="MRGRVSPIMLLLGILVLASVSATHAKSSPYQKKTENPCAQRCLQ  
 SCQQEPDDLKQKACESRCTKLEYDPRCVYDPRGHTGTTNQRSPPGERTRGRQPGDYDD  
 DRRQPRREEGGRWGPAGPREREREEDWRQPREDWRRPSHQQPRKIRPEGREGEQEWT  
 PGSHVREETSRRNPFYFSPRRFSTRYGNQNGRIRVLQRFQDQRSRQFQNLQNHRIVQIE  
 AKPNTLVLPKHADADNIIQVQGGQATVTVANGNNRKSFNLDDEGHALRIPSGFISYILN  
 RHDNQNLRVAKISMPVNTPGQFEDFFPASSRDQSSYLQGFSRNTLEAAFNAAFNEIRR  
 VLLEENAGGEQEERGQRRWSTRSSENNEGVIVKVSKEHVEELTKHAKSVSKKGSEEEG  
 DITNPINLREGEPLDLSNNFGKLFVVKPKDKNPQLQDLDMMLTCVEIKEGALMLPHFNS  
 KAMVIVVVNKG TGNLELVAVRKEQQQRGRREEEEDDEEEEGSNREVRRTARLKEGD  
 VFIMPAAHPVAINASSELHLLGFGINAENNRIFLAGDKDNVIDQIEKQAKDLAFPGS  
 GEQVEKLIKQKESHFVSARPOSQSQSPSSPEKESPEKEDQEEENQGGKGPLLSILKA  
 FN"  
 3' UTR 1931. .2032  
 polyA\_signal 2005. .2010  
 polyA\_site 2032  
 BASE COUNT 628 A 473 C 530 G 401t  
 ORIGIN

Araqarahi Length: 2032 1996 16:36 Type: N Check: 8370 ..

1 AATAATCATA TATATTCATC AATCATCTAT ATAAGTAGTA GCAGGAGCAA  
 51 TGAGAGGGAG GGTTCCTCCA CTGATGCTGT TGCTAGGGAT CCTTGTCCTG  
 101 GCTTCAGTTT CTGCAACGCA TGCCAAGTCA TCACCTTACC AGAAGAAAAC  
 151 AGAGAACCCC TGCGCCCAGA GGTGCCTCCA GAGTTGTCAA CAGGAACCGG  
 201 ATGACTTGAA GCAAAAAGGCA TGCGAGTCTC GCTGCACCAA GCTCGAGTAT

```

251  GATCCTCGTT GTGTCTATGA TCCTCGAGGA CACACTGGCA CCACCAACCA
301  ACGTTCCCTT CCAGGGGAGC GGACACGTGG CCGCCAACCC GGAGACTACG
351  ATGATGACCG CCGTCAACCC CGAAGAGAGG AAGGAGGCCG ATGGGGACCA
401  GCTGGACCGA GGGAGCGTGA AAGAGAAGAA GACTGGAGAC AACCAAGAGA
451  AGATTGGAGG CGACCAAGTC ATCAGCAGCC ACGGAAAATA AGGCCCCGAG
501  GAAGAGAAGG AGAACAAGAG TGGGGAACAC CAGGTAGCCA TGTGAGGGAA
551  GAAACATCTC GGAACAACCC TTTCTACTTC CCGTCAAGGC GGTTTAGCAC
601  CCGCTACGGG AACCAAAACG GTAGGATCCG GGTCTGCAG AGGTTTGACC
651  AAAGGTCAAG GCAGTTTCAG AATCTCCAGA ATCACCGTAT TGTGCAGATC
701  GAGGCCAAAC CTAACACTCT TGTTCTTCCC AAGCACGCTG ATGCTGATAA
751  CATCCTTGTT ATCCAGCAAG GGCAAGCCAC CGTGACCGTA GCAAATGGCA
801  ATAACAGAAA GAGCTTTAAT CTTGACGAGG GCCATGCACT CAGAATCCCA
851  TCCGGTTTCA TTTCTTACAT CTTGAACCGC CATGACAACC AGAACCTCAG
901  AGTAGCTAAA ATCTCCATGC CCGTTAACAC ACCCGGCCAG TTTGAGGATT
951  TCTTCCCGGC GAGCAGCCGA GACCAATCAT CCTACTTGCA GGGCTTCAGC
1001 AGGAATACGT TGGAGGCCGC CTTCAATGCG GAATTCAATG AGATACGGAG
1051 GGTGCTGTTA GAAGAGAATG CAGGAGGTGA GCAAGAGGAG AGAGGGCAGA
1101 GGCGATGGAG TACTCGGAGT AGTGAGAACA ATGAAGGAGT GATAGTCAAA
1151 GTGTCAAAGG AGCACGTTGA AGAACTTACT AAGCACGCTA AATCCGTCTC
1201 AAAGAAAGGC TCCGAAGAAG AGGGAGATAT CACCAACCCA ATCAACTTGA
1251 GAGAAGGCGA GCCCCATCTT TCTAACAACT TTGGGAAGTT ATTTGAGGTG
1301 AAGCCAGACA AGAAGAACCC CCAGCTTCAG GACCTGGACA TGATGCTCAC
1351 CTGTGTAGAG ATCAAAGAAG GAGCTTTGAT GCTCCACAC TTCAACTCAA
1401 AGGCCATGGT TATCGTCGTC GTCAACAAAG GAACTGGAAA CCTTGAACTC
1451 GTGGCTGTAA GAAAAGAGCA ACAACAGAGG GGACGGCGGG AAGAAGAGGA
1501 GGACGAAGAC GAAGAAGAGG AGGGAAGTAA CAGAGAGGTG CGTAGGTACA
1551 CAGCGAGGTT GAAGGAAGGC GATGTGTTCA TCATGCCAGC AGCTCATCCA
1601 GTAGCCATCA ACGCTTCCTC CGAACTCCAT CTGCTTGGCT TCGGTATCAA
1651 CGCTGAAAAC AACCACAGAA TCTTCCTTGC AGGTGATAAG GACAATGTGA
1701 TAGACCAGAT AGAGAAGCAA GCGAAGGATT TAGCATTCCC TGGGTCGGGT
1751 GAACAAGTTG AGAAGCTCAT CAAAACCAG AAGGAATCTC ACTTTGTGAG
1801 TGCTCGTCTT CAATCTCAAT CTCAATCTCC GTCGTCTCCT GAGAAAGAGT
1851 CTCCTGAGAA AGAGGATCAA GAGGAGGAAA ACCAAGGAGG GAAGGGTCCA
1901 CTCCTTTCAA TTTTGAAGGC TTTTAACTGA GAATGGAGGC AACTTGTTAT
1951 GTATCGATAA TAAGATCACG CTTTGTACT CTACTATCCA AAAACTTATC
2001 AATAAATAAA AACGTTTGTG CGTTGTTTCT CC

```

TABLE 36

GENIE> type arah2p38.pep  
 TRANSLATE of: arah2p38.final check: 9822 from: 4 to: 480  
 generated symbols 1 to: 159.

Arah2p38.Pep Length: 157 1996 15:24 Type: P Check: 2859

```

1  LTILVALALF LLAHASARQ QWELQGDRRC QSQLERANLR PCEQHLMQKI
51  QRDEDSYERD PYSPSQDPYS PSPYDRRGAG SSQHQERCCN ELNEFENNQR
101 CMCEALQQIM ENQSDRLQGR QQEQQFKREL RNLQQCGLR APQRCDLDVE
151 SGGDRY

```

In accordance with the present invention, it is contemplated that the discovery or identification of particular peptides or epitopes which bind IgE and cause an IgE response by a person having an allergy or sensitivity to that particular protein may be used to produce a DNA vaccine for immunization therapy to hopefully reduce the IgE response and thereby eliminate or reduce the negative effects of the allergy or sensitivity. For example, a protein, peptide, or epitope can be produced and injected into a patient as a DNA vaccine which hopefully will have an immuno modulation effect of the IgE response and stimulate a different response, such as IgG, IgM, IgA, etc. and thereby down regulate IgE synthesis to the specific allergen.

Also in accordance with the present invention, similar peptides, epitopes and IgE binding proteins from other legumes, herbs, oil seeds, and the like, for example soybeans or wheat, can be isolated and identified, mutated so that they do not bind IgE, and used in a mutated DNA vaccine for immunization therapy.

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

- (i) APPLICANT: BURKS, A Wesley, HELM, Ricki M,  
COCKRELL, Gael, STANLEY, J Steven,  
BANNON, Gary A
- (ii) TITLE OF INVENTION: PEANUT ALLERGENS AND  
METHODS
- (iii) NUMBER OF SEQUENCES: 67
- (iv) CORRESPONDENCE ADDRESS:
  - (A) ADDRESSEE: Head, Johnson & Kachigian
  - (B) STREET: 112 W. Center St., Suite 230
  - (C) CITY: Fayetteville
  - (D) STATE: Arkansas AR
  - (E) COUNTRY: United States of America
  - (F) ZIP: 72701
- (v) COMPUTER READABLE FORM:
  - (A) MEDIUM TYPE: Diskette, 3.50 inch, 1.44 Mb  
storage
  - (B) COMPUTER: IBM PC compatible
  - (C) OPERATING SYSTEM: MS-DOS 6.2
  - (D) SOFTWARE: Wordperfect 6.0C
- (vi) CURRENT APPLICATION DATA:
  - (A) APPLICATION NUMBER: PCTUS96/15,222
  - (B) FILING DATE: 23 SEPTEMBER 1996
  - (C) CLASSIFICATION:
- (vii) PRIOR APPLICATION DATA:
  - (A) APPLICATION NUMBER: US 07/998,377

- (B) FILING DATE: 30 DECEMBER 1992
- (C) APPLICATION NUMBER: US 08/158,704
- (D) FILING DATE: 29 NOVEMBER 1993
- (E) APPLICATION NUMBER: US 60/009,455
- (F) FILING DATE: 29 DECEMBER 1995
- (G) APPLICATION NUMBER: US 08/610,424
- (H) FILING DATE: 04 MARCH 1996

(viii) ATTORNEY/AGENT INFORMATION:

- (A) NAME: ALEXANDER, DANIEL R
- (B) REGISTRATION NUMBER: 32,604
- (C) REFERENCE/DOCKET NUMBER: ARK00895601A

(ix) TELECOMMUNICATION INFORMATION:

- (A) TELEPHONE: (501) 521-4412
- (B) TELEFAX: Not applicable
- (C) TELEX: Not applicable

(2) INFORMATION FOR SEQ ID NO: 1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 32 amino acid residues
- (B) TYPE: Amino acid sequence
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: Unknown

(ii) MOLECULE TYPE: Glycoprotein

- (A) DESCRIPTION: 32 N-terminal amino acid residue sequence of a 17 kD protein/allergen (upper band) isolated from a crude extract of peanuts (*Arachis hypogaea* L.) identified as Ara h II (IUIS/WHO)

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: N-terminal fragment

- (vi) ORIGINAL SOURCE:
- (A) ORGANISM: *Arachis hypogaea* L.
  - (B) STRAIN: Southeastern runners
  - (C) INDIVIDUAL ISOLATE: Commercial lots North Carolina State Univ.
  - (D) DEVELOPMENT STAGE: Mature raw peanuts
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE: Mature peanuts
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE: Crude soluble whole peanut extract
- (A) LIBRARY: Not applicable
  - (B) CLONE: Not applicable
- (viii) POSITION IN GENOME: Not applicable
- (ix) FEATURE:
- (A) NAME/KEY:
  - (B) LOCATION: Not registered
  - (C) IDENTIFICATION METHOD: Not completed
  - (D) OTHER INFORMATION: Ara h II allergen isolated from crude extract of *Arachis hypogaea* L with an apparent molecular wt of 17 kD that binds to IgE in human serum from patients with peanut immediate hypersensitivity
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:

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- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:

Xaa	Gln	Gln	Xaa	Glu	Leu	Gln	Xaa	Asp	Xaa	Xaa
1				5					10	
Xaa	Gln	Ser	Gln	Leu	Glu	Arg	Ala	Asp	Leu	Arg
			15					20		
Pro	Gly	Glu	Gln	Xaa	Leu	Met	Xaa	Lys	Ile	
		25					30			

(2) INFORMATION FOR SEQ ID NO: 2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 32 amino acid residues
- (B) TYPE: Amino acid sequence
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: Unknown

(ii) MOLECULE TYPE: Glycoprotein

- (A) DESCRIPTION: 32 N-terminal amino acid residue sequence of a 17 kD protein/allergen (lower band) isolated from a crude extract of peanuts (*Arachis hypogaea* L.) identified as Ara h II (IUIS/WHO)

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: N-terminal fragment

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: *Arachis hypogaea* L.
- (B) STRAIN: Southeastern runners
- (C) INDIVIDUAL ISOLATE: Commercial lots North Carolina State Univ.



- (D) DEVELOPMENT STAGE: Mature raw peanuts
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE: Mature peanuts
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE: Crude soluble whole peanut extract
  - (A) LIBRARY: Not applicable
  - (B) CLONE: Not applicable
- (viii) POSITION IN GENOME: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION: Not registered
  - (C) IDENTIFICATION METHOD: Not completed
  - (D) OTHER INFORMATION: Ara h II allergen isolated from crude extract of *Arachis hypogaea* L with an apparent molecular wt of 17 kD that binds to IgE in human serum from patients with peanut immediate hypersensitivity
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 2:

Xaa	Gln	Gln	Xaa	Glu	Leu	Gln	Asp	Leu	Glu	Xaa
1				5					10	
Xaa	Gln	Ser	Gln	Leu	Glu	Asp	Ala	Asn	Leu	Arg
			15					20		
Pro	Arg	Glu	Gln	Xaa	Leu	Met	Xaa	Lys	Ile	
		25					30			

(2) INFORMATION FOR SEQ ID NO: 3:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 9 amino acid residues

(B) TYPE: Amino acid sequence

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: Unknown

(ii) MOLECULE TYPE: Glycoprotein

(A) DESCRIPTION: 9 N-terminal amino acid residue sequence of a 17 kD protein/allergen (lower band) isolated from a crude extract of peanuts (*Arachis hypogaea* L.) identified as Ara h II (IUIS/WHO)

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: N-terminal fragment

(vi) ORIGINAL SOURCE:

(A) ORGANISM: *Arachis hypogaea* L.

(B) STRAIN: Southeastern runners

(C) INDIVIDUAL ISOLATE: Commercial lots North Carolina State Univ.

(D) DEVELOPMENT STAGE: Mature raw peanuts

(E) HAPLOTYPE: Not applicable

(F) TISSUE TYPE: Mature peanuts

(G) CELL TYPE: Not applicable

- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE: Crude soluble whole peanut extract
  - (A) LIBRARY: Not applicable
  - (B) CLONE: Not applicable
- (viii) POSITION IN GENOME: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION: Not registered
  - (C) IDENTIFICATION METHOD: Not completed
  - (D) OTHER INFORMATION: Ara h II allergen isolated from crude extract of *Arachis hypogaea* L with an apparent molecular wt of 17 kD that binds to IgE in human serum from patients with peanut immediate hypersensitivity
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 3:  

Xaa	Gln	Gln	Xaa	Glu	Leu	Gln	Asp	Leu
1				5				

## (2) INFORMATION FOR SEQ ID NO: 4:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1949 bases
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: cDNA to mRNA

- (A) DESCRIPTION: identified as Ara h I Alpha P17

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: No

## (v) FRAGMENT TYPE: Not applicable

## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Clone P17
- (D) DEVELOPMENT STAGE: Seed
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE: Seed mRNA, cDNA library
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

- (A) LIBRARY: Florunner seed cDNA expression library in Uni-ZAP XR vector
- (B) CLONE: P17

## (viii) POSITION IN GENOME:

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY: CDS

(B) LOCATION: 3..1847

(C) IDENTIFICATION METHOD: By agreement with  
protein information and established  
consensus sequence

(D) OTHER INFORMATION: Seed storage protein and  
allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 4:

CAATGAGAGG GAGGGTTTCT CCACTGATGC TGTTGCTTGG GATCCTTGTC 050  
CTGGCTTCAG TTTCTGCAAC GCAGGCCAAG TCACCTTACC GGAAAACAGA 100  
GAACCCCTGC GCCCAGAGGT GCCTCCAGAG TTGTCAACAG GAACCGGACG 150  
ACTTGAAGCA AAAGGCATGC GAGTCTCGCT GCACCAAGCT CGAGTATGAT 200  
CCTCGTTGTG TCTATGACAC TGGCGCCACC AACCAACGTC ACCCTCCAGG 250  
GGAGCGGACA CGTGGCCGCC AACCCGGAGA CTACGATGAT GACCGCCGTC 300  
AACCCCGAAG AGAGGAAGGA GGCCGATGGG GACCAGCTGA ACCGAGGGAG 350

CGTGAAAGAG AAGAAGACTG GAGACAACCA AGAGAAGATT GGAGGCGACC 400  
AAGTCATCAG CAGCCACGGA AAATAAGGCC CGAAGGAAGA GAAGGAGAAC 450  
AAGAGTGGGG AACACCAGGT AGCGAGGTGA GGAAGAAAC ATCACGGAAC 500  
AACCCTTTCT ACTTCCCGTC AAGGCGGTTT AGCACCCGCT ACGGGAACCA 550  
AAACGGTAGG ATCCGCGTCC TGCAGAGGTT TGACCAAAGG TCAAAGCAGT 600  
TTCAGAATCT CCAGAATCAC CGTATTGTGC AGATCGAGGC CAGACCTAAC 650  
ACTCTTGTTT TTCCCAAGCA CGCTGATGCT GATAACATCC TTGTTATCCA 700  
GCAAGGACAA GCCACCGTGA CCGTAGCAA TGGCAATAAC AGAAAGAGCT 750  
TTAATCTTGA CGAGGGCCAT GCACTCAGAA TCCCATCCGG TTTCATTTCC 800  
TACATCTTGA ATCGACATGA CAACCAGAAC CTCAGAGTAG CTAAAATCTC 850  
CATGCCCCGT AACACGCCCCG GCCAGTTTGA GGATTTCTTC CCGGCGAGCA 900  
GCCGAGACCA ATCATCCTAC TTGCAGGGAT TCAGCAGGAA TACTTTGGAG 950  
GCCGCCTTCA ATGCGGAATT CAATGAGATA CGGAGGGTGC TGTTAGAAGA 1000  
GAATGCAGGA GGAGAGCAAG AGGAGAGAGG GCAGAGGCGA CGGAGTACTC 1050  
GGAGTAGTGA TAATGAAGGA GTGATAGTCA AAGTGTCAA GGAGCACGTT 1100  
CAAGAACTTA CTAAGCACGC TAAATCCGTC TCAAAGAAAG GCTCCGAAGA 1150  
GGAAGATATC ACCAACCCTA TCAACTTGAG AGATGGCGAG CCCGATCTTT 1200  
CTAACAACCT TGGGAGGTTA TTTGAGGTGA AGCCAGACAA GAAGAACCCC 1250  
CAGCTTCAGG ACCTGGACAT GATGCTCACC TGTGTAGAGA TCAAAGAAGG 1300  
AGCTTTGATG CTCCCACACT TCAACTCAA GGCCATGGTC ATCGTCGTCG 1350  
TCAACAAAGG AACTGGAAAC CTTGAACTCG TAGCTGTAAG AAAAGAGCAA 1400  
CAACAGAGGG GACGGCGGGA ACAAGAGTGG GAAGAAGAGG AGGAAGATGA 1450  
AGAAGAGGAG GGAAGTAACA GAGAGGTGCG TAGGTACACA GCGAGGTTGA 1500  
AGGAAGGCGA TGTGTTTCATC ATGCCAGCAG CTCATCCAGT AGCCATCAAC 1550  
GCTTCCTCCG AACTCCATCT GCTTGGCTTC GGTATCAACG CTGAAAACAA 1600  
CCACAGAATC TTCCTTGCAG GTGATAAGGA CAATGTGATA GACCAGATAG 1650  
AGAAGCAAGC GAAGGATTTA GCATTCCCTG GTTCGGGTGA ACAAGTTGAG 1700

AAGCTCATCA AAAACCAGAG GGAGTCTCAC TTTGTGAGTG CTCGTCCTCA 1750  
ATCTCAATCT CCGTCGTCTC CTGAAAAAGA GGATCAAGAG GAGGAAAACC 1800  
AAGGAGGGAA GGGTCCACTC CTTTCAATTT TGAAGGCTTT TAACTGAGAA 1850  
TGGAGGAAAC TTGTTATGTA TCCATAATAA GATCACGCTT TTGTAATCTA 1900  
CTATCCAAAA ACTTATCAAT AAATAAAAAC GTTGTGCGT TGTTTCTCC 1949

(2) INFORMATION FOR SEQ ID NO: 5:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 2032 bases
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA to mRNA

- (A) DESCRIPTION: identified as Ara h I Beta P41b

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: No

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Clone P41b
- (D) DEVELOPMENT STAGE: Seed
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE: Seed mRNA, cDNA library
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

(A) LIBRARY: Florunner seed cDNA expression library in Uni-ZAP XR vector

(B) CLONE: P41b

(viii) POSITION IN GENOME:

(A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY: CDS

(B) LOCATION: 50..1930

(C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence

(D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 5:

AATAATCATA TATATTCATC AATCATCTAT ATAAGTAGTA GCAGGAGCAA 050



TGAGAGGGAG	GGTTTCTCCA	CTGATGCTGT	TGCTAGGGAT	CCTTGTCTTG	100
GCTTCAGTTT	CTGCAACGCA	TGCCAAGTCA	TCACCTTACC	AGAAGAAAAC	150
AGAGAACCCC	TGCGCCCAGA	GGTGCCTCCA	GAGTTGTCAA	CAGGAACCGG	200
ATGACTTGAA	GCAAAAGGCA	TGCGAGTCTC	GCTGCACCAA	GCTCGAGTAT	250
GATCCTCGTT	GTGTCTATGA	TCCTCGAGGA	CACACTGGCA	CCACCAACCA	300
ACGTTCCCCT	CCAGGGGAGC	GGACACGTGG	CCGCCAACCC	GGAGACTACG	350
ATGATGACCG	CCGTCAACCC	CGAAGAGAGG	AAGGAGGCCG	ATGGGGACCA	400
GCTGGACCGA	GGGAGCGTGA	AAGAGAAGAA	GA CTGGAGAC	AACCAAGAGA	450
AGATTGGAGG	CGACCAAGTC	ATCAGCAGCC	ACGGAAAATA	AGGCCCCGAAG	500
GAAGAGAAGG	AGAACAAGAG	TGGGGAACAC	CAGGTAGCCA	TGTGAGGGAA	550
GAAACATCTC	GGAACAACCC	TTTCTACTTC	CCGTCAAGGC	GGTTTAGCAC	600
CCGCTACGGG	AACCAAACG	G TAGGATCCG	GGTCCTGCAG	AGGTTTGACC	650
AAAGGTCAAG	GCAGTTTCAG	AATCTCCAGA	ATCACCGTAT	TGTGCAGATC	700
GAGGCCAAAC	CTAACACTCT	TGTTCTTCCC	AAGCACGCTG	ATGCTGATAA	750
CATCCTTGTT	ATCCAGCAAG	GGCAAGCCAC	CGTGACCGTA	GCAAATGGCA	800
ATAACAGAAA	GAGCTTTAAT	CTTGACGAGG	GCCATGCACT	CAGAATCCCA	850
TCCGGTTTCA	TTTCCTACAT	CTTGAACCGC	CATGACAACC	AGAACCTCAG	900
AGTAGCTAAA	ATCTCCATGC	CCGTAAACAC	ACCCGGCCAG	TTTGAGGATT	950
TCTTCCC GGC	GAGCAGCCGA	GACCAATCAT	CCTACTTGCA	GGGCTTCAGC	1000
AGGAATACGT	TGGAGGCCGC	CTTCAATGCG	GAATTCAATG	AGATACGGAG	1050
GGTGCTGTTA	GAAGAGAATG	CAGGAGGTGA	GCAAGAGGAG	AGAGGGCAGA	1100
GGCGATGGAG	TACTCGGAGT	AGTGAGAACA	ATGAAGGAGT	GATAGTCAAA	1150
GTGTCAAAGG	AGCACGTTGA	AGAACTTACT	AAGCACGCTA	AATCCGTCTC	1200
AAAGAAAGGC	TCCGAAGAAG	AGGGAGATAT	CACCAACCCA	ATCAACTTGA	1250
GAGAAGGCGA	GCCCCATCTT	TCTAACAACT	TTGGGAAGTT	ATTTGAGGTG	1300
AAGCCAGACA	AGAAGAACCC	CCAGCTTCAG	GACCTGGACA	TGATGCTCAC	1350
CTGTGTAGAG	ATCAAAGAAG	GAGCTTTGAT	GCTCCCACAC	TTCAACTCAA	1400

AGGCCATGGT TATCGTCGTC GTCAACAAAG GAACTGGAAA CCTTGAAGTC 1450  
GTGGCTGTAA GAAAAGAGCA ACAACAGAGG GGACGGCGGG AAGAAGAGGA 1500  
GGACGAAGAC GAAGAAGAGG AGGGAAGTAA CAGAGAGGTG CGTAGGTACA 1550  
CAGCGAGGTT GAAGGAAGGC GATGTGTTCA TCATGCCAGC AGCTCATCCA 1600  
GTAGCCATCA ACGCTTCCTC CGAACTCCAT CTGCTTGGCT TCGGTATCAA 1650  
CGCTGAAAAC AACCACAGAA TCTTCCTTGC AGGTGATAAG GACAATGTGA 1700  
TAGACCAGAT AGAGAAGCAA GCGAAGGATT TAGCATTCCTC TGGGTCGGGT 1750  
GAACAAGTTG AGAAGCTCAT CAAAAACCAG AAGGAATCTC ACTTTGTGAG 1800  
TGCTCGTCCT CAATCTCAAT CTCAATCTCC GTCGTCTCCT GAGAAAGAGT 1850  
CTCCTGAGAA AGAGGATCAA GAGGAGGAAA ACCAAGGAGG GAAGGGTCCA 1900  
CTCCTTTCAA TTTTGAAGGC TTTTAACTGA GAATGGAGGC AACTTGTTAT 1950  
GTATCGATAA TAAGATCACG CTTTGTACT CTACTATCCA AAAACTTATC 2000  
AATAAATAAA AACGTTTGTG CGTTGTTTCT CC 2032

(2) INFORMATION FOR SEQ ID NO: 6:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 717 bases
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA to mRNA

- (A) DESCRIPTION: identified as Ara h II P38

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: No

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: *Arachis hypogaea*
- (B) STRAIN: Florunner

- (C) INDIVIDUAL ISOLATE: Clone P38
- (D) DEVELOPMENT STAGE: Seed
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE: Seed mRNA, cDNA library
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY: Florunner seed cDNA expression library in Uni-ZAP XR vector
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY: CDS
  - (B) LOCATION: 2..475
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:

- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 6:

GCTCACCATA CTAGTAGCCC TCGCCCTTTT CCTCCTCGCT GCCCACGCAT	050
CTGCGAGGCA GCAGTGGGAA CTCCAAGGAG ACAGAAGATG CCAGAGCCAG	100
CTCGAGAGGG CGAACCTGAG GCCCTGCGAG CAACATCTCA TGCAGAAGAT	150
CCAACGTGAC GAGGATTCAT ATGAACGGGA CCCGTACAGC CCTAGTCAGG	200
ATCCGTACAG CCCTAGTCCA TATGATCGGA GAGGCGCTGG ATCCTCTCAG	250
CACCAAGAGA GGTGTTGCAA TGAGCTGAAC GAGTTTGAGA ACAACCAAAG	300
GTGCATGTGC GAGGCATTGC AACAGATCAT GGAGAACCAG AGCGATAGGT	350
TGCAGGGGAG GCAACAGGAG CAACAGTTCA AGAGGGAGCT CAGGAACTTG	400
CCTCAACAGT GCGGCCTTAG GGCACCACAG CGTTGCGACT TGGACGTCGA	450
AAGTGGCGGC AGAGACAGAT ACTAAACACC TATCTCAAAA AAAGAAAAGA	500
AAAGAAAAGA AAATAGCTTA TATATAAGCT ATTATCTATG GTTATGTTTA	550
GTTTTGGTAA TAATAAAGAT CATCACTATA TGAATGTGTT GATCGTGTTA	600
ACTAAGGCAA GCTTAGGTTA TATGAGCACC TTTAGAGTGC TTTTATGGCG	650
TTGTCTATGT TTTGTTGCTG CAGAGTTGTA ACCATCTTGA AATAATATAA	700
AAAGATCATG TTTTGTT	717

(2) INFORMATION FOR SEQ ID NO: 7:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 18 amino acid residues
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable

- (D) TOPOLOGY: Unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h 2 Peptide I.  
The amino acid sequence of the amino terminus (I)  
and a tryptic peptide (II) derived from Ara h 2  
protein.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: amino terminus
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE:
  - (D) DEVELOPMENT STAGE: seed
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE: seed
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:

- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 7:

Xaa	Gln	Gln	Trp	Glu	Leu	Gln	Gly	Asp	Arg	Arg	Arg	Gln	Ser	Gln
1				5					10					15
Leu	Glu	Arg												

(2) INFORMATION FOR SEQ ID NO: 8:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 13 amino acid residues
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: Unknown

(ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h 2 Peptide II. The amino acid sequence of the amino terminus (I) and a tryptic peptide (II) derived from Ara h 2 protein.

- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: peptide
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE:
  - (D) DEVELOPMENT STAGE: seed
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE: seed
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 8:

Ala Asn Leu Arg Pro Cys Glu Gln His Leu Met Gln Lys  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 9:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 717 nucleotides
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: cDNA

- (A) DESCRIPTION: identified as Ara h II cDNA clone

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: No

## (v) FRAGMENT TYPE: Not applicable

## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea



- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE:
- (D) DEVELOPMENT STAGE: seed
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE: seed cDNA
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY: florunner seed cDNA expression library in Uni-ZAP XR vector
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:

- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 9:

```
G CTC ACC ATA CTA GTA GCC CTC GCC CTT TTC CTC CTC GCT GCC      43
CAC GCA TCT GCG AGG CAG CAG TGG GAA CTC CAA GGA GAC AGA AGA    91
TGC CAG AGC CAG CTC GAG AGG GCG AAC CTG AGG CCC TGC GAG CAA 139
CAT CTC ATG CAG AAG ATC CAA CGT GAC GAG GAT TCA TAT GAA CGG 187
GAC CCG TAC AGC CCT AGT CAG GAT CCG TAC AGC CCT AGT CCA TAT 235
GAT CGG AGA GGC GCT GGA TCC TCT CAG CAC CAA GAG AGG TGT TGC 283
AAT GAG CTG AAC GAG TTT GAG AAC AAC CAA AGG TGC ATG TGC GAG 331
GCA TTG CAA CAG ATC ATG GAG AAC CAG AGC GAT AGG TTG CAG GGG 379
AGG CAA CAG GAG CAA CAG TTC AAG AGG GAG CTC AGG AAC TTG CCT 427
CAA CAG TGC GGC CTT AGG GCA CCA CAG CGT TGC GAC TTG GAC GTC 475
GAA AGT GGC GGC AGA GAC AGA TAC TAA                               502
ACACCTATCT CAAAAAAGA AAAGAAAAGA AAAGAAAATA GCTTATATAT        50
AAGCTATTAT CTATGGTTAT GTTTAGTTTT GGTAATAATA AAGATCATCA       100
CTATATGAAT GTGTTGATCG TGTAACTAA GGCAAGCTTA GGTTATATGA       150
GCACCTTTAG AGTGCTTTTA TGGCGTTGTC TATGTTTTGT TGCTGCAGAG      200
TTGTAACCAT CTTGAAATAA TATAAAAAGA TCATGTTTTG TT                242
```

(2) INFORMATION FOR SEQ ID NO: 10:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 157 amino acids

- (B) TYPE: amino acid
- (C) STRANDEDNESS: not applicable
- (D) TOPOLOGY: Unknown
- (ii) MOLECULE TYPE: cDNA
  - (A) DESCRIPTION: identified as Ara h II cDNA clone derived amino acid sequence
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: No
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE:
  - (D) DEVELOPMENT STAGE: seed
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE: seed cDNA
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:

- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 10:

```

Leu Thr Ile Leu Val Ala Leu Ala Leu Phe Leu Leu Ala Ala
 1          5          10
His Ala Ser Ala Arg Gln Gln Trp Glu Leu Gln Gly Asp Arg Arg Cys
15          20          25          30
Gln Ser Gln Leu Glu Arg Ala Asn Leu Arg Pro Cys Glu Gln His Leu
          35          40          45
Met Gln Lys Ile Gln Arg Asp Glu Asp Ser Tyr Glu Arg Asp Pro Tyr
          50          55          60
Ser Pro Ser Gln Asp Pro Tyr Ser Pro Ser Pro Tyr Asp Arg Arg Gly
          65          70          75
Ala Gly Ser Ser Gln His Gln Glu Arg Cys Cys Asn Glu Leu Asn Glu
          80          85          90
Phe Glu Asn Asn Gln Arg Cys Met Cys Glu Ala Leu Gln Gln Ile Met
95          100          105          110
Glu Asn Gln Ser Asp Arg Leu Gln Gly Arg Gln Gln Glu Gln Gln Phe
          115          120          125
Lys Arg Glu Leu Arg Asn Leu Pro Gln Gln Cys Gly Leu Arg Ala Pro
          130          135          140
Gln Arg Cys Asp Leu Asp Val Glu Ser Gly Gly Arg Asp Arg Tyr

```

145

150

155

## (2) INFORMATION FOR SEQ ID NO: 11:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

## (ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 1 Ara h 2 position 15-24, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: Not applicable

## (v) FRAGMENT TYPE: Not applicable

## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h II
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE:

## (viii) POSITION IN GENOME:

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable
- (C) UNITS: Not applicable

(ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 11:

His Ala Ser Ala Arg Gln Gln Trp Glu Leu  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 12:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids

201

- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 2 Ara h 2 position 21-30, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:

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- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 12:

Gln	Trp	Glu	Leu	Gln	Gly	Asp	Arg	Arg	Cys
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 13
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein



(A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 3 Ara h 2 position 27-36, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

(A) ORGANISM: Arachis hypogaea

(B) STRAIN: Florunner

(C) INDIVIDUAL ISOLATE: Ara h II

(D) DEVELOPMENT STAGE:

(E) HAPLOTYPE: Not applicable

(F) TISSUE TYPE:

(G) CELL TYPE: Not applicable

(H) CELL LINE: Not applicable

(I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(viii) POSITION IN GENOME:

(A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY:

(B) LOCATION:

(C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence

(D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 13:

Asp	Arg	Arg	Cys	Gln	Ser	Gln	Leu	Glu	Arg
1				5					10

(2) INFORMATION FOR SEQ ID NO: 14:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 4 Ara h 2 position 39-48, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II
  - (D) DEVELOPMENT STAGE: .
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:

- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 14:

Leu	Arg	Pro	Cys	Glu	Gln	His	Leu	Met	Gln
1				5					10

(2) INFORMATION FOR SEQ ID NO: 15:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 5 Ara h 2 position 49-58, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner

- (C) INDIVIDUAL ISOLATE: Ara h II
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:

- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 15:
- |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Lys | Ile | Gln | Arg | Asp | Glu | Asp | Ser | Tyr | Glu |
| 1   |     |     |     | 5   |     |     |     |     | 10  |
- (2) INFORMATION FOR SEQ ID NO: 16:
- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 6 Ara h 2 position 57-66, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h II
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:

- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:

## (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 16:

Tyr	Glu	Arg	Asp	Pro	Tyr	Ser	Pro	Ser	Gln
1				5					10

(2) INFORMATION FOR SEQ ID NO: 17:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 7 Ara h 2 position 65-74, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

(A) ORGANISM: Arachis hypogaea

(B) STRAIN: Florunner

(C) INDIVIDUAL ISOLATE: Ara h II

(D) DEVELOPMENT STAGE:

(E) HAPLOTYPE: Not applicable

(F) TISSUE TYPE:

(G) CELL TYPE: Not applicable

(H) CELL LINE: Not applicable

(I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:



- (A) LIBRARY:
- (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 17:  
Ser Gln Asp Pro Tyr Ser Pro Ser Pro Tyr  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 18:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

## (ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 8 Ara h 2 position 115-124, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: Not applicable

## (v) FRAGMENT TYPE: Not applicable

## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h II
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE:

## (viii) POSITION IN GENOME:

- (A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY:

(B) LOCATION:

(C) IDENTIFICATION METHOD: By agreement with  
protein information and established  
consensus sequence

(D) OTHER INFORMATION: Seed storage protein and  
allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 18:

Asp	Arg	Leu	Gln	Gly	Arg	Gln	Gln	Glu	Gln
1				5					10

(2) INFORMATION FOR SEQ ID NO: 19:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide 9 Ara h 2 position 127-136, epitope represents synthesized amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:

- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 19:
- |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Lys | Arg | Glu | Leu | Arg | Asn | Leu | Pro | Gln | Gln |
| 1   |     |     |     | 5   |     |     |     |     | 10  |
- (2) INFORMATION FOR SEQ ID NO: 20:
- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h 2 IgE binding epitope peptide  
10 Ara h 2 position 143-152, epitope represents synthesized

amino acid sequence derived from the amino acid sequence of the translated nucleotide sequence reading frame of the clone.

- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and

## allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 20:

Gln Arg Cys Asp Leu Asp Val Glu Ser Gly  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 21:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 157 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

## (ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h 2 P38 deduced sequence from nucleotide sequence reading frame.

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: Not applicable

## (v) FRAGMENT TYPE: Not applicable

- (vi) ORIGINAL SOURCE:
- (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
- (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
- (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
- (A) NAME/KEY: final check
  - (B) LOCATION: 4..480
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:



- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 21:

Leu	Thr	Ile	Leu	Val	Ala	Leu	Ala	Leu	Phe	
1				5					10	
Leu	Leu	Ala	Ala	His	Ala	Ser	Ala	Arg	Gln	
				15					20	
Gln	Trp	Glu	Leu	Gln	Gly	Asp	Arg	Arg	Cys	
				25					30	
Gln	Ser	Gln	Leu	Glu	Arg	Ala	Asn	Leu	Arg	
				35					40	
Pro	Cys	Glu	Gln	His	Leu	Met	Gln	Lys	Ile	
				45					50	
Gln	Arg	Asp	Glu	Asp	Ser	Tyr	Glu	Arg	Asp	
				55					60	
Pro	Ser	Tyr	Pro	Ser	Gln	Asp	Pro	Tyr	Ser	
				65					70	
Pro	Ser	Pro	Tyr	Asp	Arg	Arg	Gly	Ala	Gly	
				75					80	
Ser	Ser	Gln	His	Gln	Glu	Arg	Cys	Cys	Asn	
				85					90	
Glu	Leu	Asn	Glu	Phe	Glu	Asn	Asn	Gln	Arg	
				95					100	
Cys	Met	Cys	Glu	Ala	Leu	Gln	Gln	Ile	Met	
				105					110	
Glu	Asn	Gln	Ser	Asp	Arg	Leu	Gln	Gly	Arg	
				115					120	
Gln	Gln	Glu	Gln	Gln	Phe	Lys	Arg	Glu	Leu	
				125					130	
Arg	Asn	Leu	Pro	Gln	Gln	Cys	Gly	Leu	Arg	
				135					140	
Ala	Pro	Gln	Arg	Cys	Asp	Leu	Asp	Val	Glu	
				145					150	
Ser	Gly	Gly	Arg	Asp	Arg	Tyr				
				155						

(2) INFORMATION FOR SEQ ID NO: 22:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 26 nucleotides
- (B) TYPE: nucleotide
- (C) STRANDEDNESS: unknown
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: OLIGONUCLEOTIDE
  - (A) DESCRIPTION: identified as amino terminus of Ara h 2 peanut allergen (peptide I).
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: amino terminus
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE:
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen, the GA(TC) represent two different forms of a trinucleotide sequence: GAT or GAC; therefore the correct nucleotide sequence is numbered differently.

(x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 22:

CARCARTGGG ARTTRCARGG NGAYAG

26

(2) INFORMATION FOR SEQ ID NO: 23:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 23 nucleotides
- (B) TYPE: nucleotide
- (C) STRANDEDNESS: unknown
- (D) TOPOLOGY: unknown

- (ii) MOLECULE TYPE: oligonucleotide
  - (A) DESCRIPTION: identified as oligonucleotide derived from amino acid sequence within peptide I of Ara h I (63.5 KD).
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN:
  - (C) INDIVIDUAL ISOLATE:
  - (D) DEVELOPMENT STAGE: mature raw peanut
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE: mature peanut
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE: crude soluble whole peanut extract
  - (A) LIBRARY: Not applicable
  - (B) CLONE: Not applicable
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with

223

protein information and established  
consensus sequence

- (D) OTHER INFORMATION: Seed storage protein and allergen, the GA(TC) represent two different forms of a trinucleotide sequence: GAT or GAC; therefore the correct nucleotide sequence is numbered differently.

(x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 23:

GAYAARGAYA AYG TNATHGA YCA

23

(2) INFORMATION FOR SEQ ID NO: 24:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 1 Ara h I position 25-34.

- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 24:  
Ala Lys Ser Ser Pro Tyr Gln Lys Lys Thr  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 25:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 10 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: Not applicable
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 2 Ara h I position 48-57.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea

- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:



- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 25:  

Gln	Glu	Pro	Asp	Asp	Leu	Lys	Gln	Lys	Ala
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 26:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 3 Ara h I position 65-74.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h I
    - (D) DEVELOPMENT STAGE:
    - (E) HAPLOTYPE: Not applicable
    - (F) TISSUE TYPE:

- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 26:

Leu Glu Tyr Pro Pro Arg Leu Val Tyr Asp  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 27:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 4 Ara h I position 89-98.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

- (A) LIBRARY:

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(B) CLONE:

(viii) POSITION IN GENOME:

(A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY:

(B) LOCATION:

(C) IDENTIFICATION METHOD: By agreement with  
protein information and established  
consensus sequence(D) OTHER INFORMATION: Seed storage protein and  
allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 27:

Gly	Glu	Arg	Thr	Arg	Gly	Arg	Gln	Pro	Gly
1				5					10

(2) INFORMATION FOR SEQ ID NO: 28:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 10 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: Not applicable
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 5 Ara h I position 97-105.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable

## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 28:

Pro Gly Asp Tyr Asp Asp Asp Arg Arg Gln  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 29:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 6 Ara h I position 107-116.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence

- (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 29:
- |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Pro | Arg | Arg | Glu | Glu | Gly | Gly | Arg | Trp | Gly |
| 1   |     |     |     | 5   |     |     |     |     | 10  |
- (2) INFORMATION FOR SEQ ID NO: 30:
- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 7 Ara h I position 123-132.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable



- (vi) ORIGINAL SOURCE:
- (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
- (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
- (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
- (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:

- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 30:  
Arg Glu Arg Glu Glu Asp Trp Arg Glu Pro  
1 5 10
- (2) INFORMATION FOR SEQ ID NO: 31:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 8 Ara h I position 134-143.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h I
    - (D) DEVELOPMENT STAGE:

- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:

- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 31:  
Glu Asp Trp Arg Arg Pro Ser His Gln Gln  
1 5 10
- (2) INFORMATION FOR SEQ ID NO: 32:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid sequence
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 9 Ara h I position 143-152.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h I
    - (D) DEVELOPMENT STAGE:
    - (E) HAPLOTYPE: Not applicable
    - (F) TISSUE TYPE:
    - (G) CELL TYPE: Not applicable
    - (H) CELL LINE: Not applicable
    - (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

## (viii) POSITION IN GENOME:

(A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

## (ix) FEATURE:

(A) NAME/KEY:

(B) LOCATION:

(C) IDENTIFICATION METHOD: By agreement with  
protein information and established  
consensus sequence(D) OTHER INFORMATION: Seed storage protein and  
allergen

## (x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 32:

240

Gln Pro Arg Lys Ile Arg Pro Glu Gly Arg  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 33:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

## (ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 10 Ara h I position 294-303.

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: Not applicable

## (v) FRAGMENT TYPE: Not applicable

## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE:

## (viii) POSITION IN GENOME:

241

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable
- (C) UNITS: Not applicable

## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 33:

Thr Pro Gly Gln Phe Glu Asp Phe Phe Pro  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 34:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids

- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 11 Ara h I position 311-320.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:



- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 34:
- |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ser | Tyr | Leu | Gln | Glu | Phe | Ser | Arg | Asn | Thr |
| 1   |     |     |     | 5   |     |     |     |     | 10  |
- (2) INFORMATION FOR SEQ ID NO: 35:
- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 12 Ara h I position 325-334.

- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 35:

Phe	Asn	Ala	Glu	Phe	Asn	Glu	Ile	Arg	Arg
1				5					10

(2) INFORMATION FOR SEQ ID NO: 36:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 13 Ara h I position 344-353.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea

- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:

- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 36:  

Glu	Gln	Glu	Glu	Arg	Gly	Gln	Arg	Arg	Trp
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 37:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 14 Ara h I position 393-402.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h I
    - (D) DEVELOPMENT STAGE:
    - (E) HAPLOTYPE: Not applicable
    - (F) TISSUE TYPE:

- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 37:

Asp Ile Thr Asn Pro Ile Asn Leu Arg Glu  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 38:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 15 Ara h I position 409-418.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

- (A) LIBRARY:

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(B) CLONE:

(viii) POSITION IN GENOME:

(A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY:

(B) LOCATION:

(C) IDENTIFICATION METHOD: By agreement with  
protein information and established  
consensus sequence(D) OTHER INFORMATION: Seed storage protein and  
allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 38:

Asn	Asn	Phe	Gly	Lys	Leu	Phe	Glu	Val	Lys
1				5					10

(2) INFORMATION FOR SEQ ID NO: 39:



- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 10 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: Not applicable
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 16 Ara h I position 461-470.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable

## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 39:

Gly Thr Gly Asn Leu Glu Leu Val Ala Val  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 40:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 17 Ara h I position 498-507.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence

(D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 40:

Arg	Arg	Tyr	Thr	Ala	Arg	Leu	Lys	Glu	Gly
1				5					10

(2) INFORMATION FOR SEQ ID NO: 41:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 18 Ara h I position 525-534.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:

- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 41:  

Glu	Leu	His	Leu	Leu	Gly	Phe	Gly	Ile	Asn
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 42:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 19 Ara h I position 539-548.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h I
    - (D) DEVELOPMENT STAGE:

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- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:

- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 42:
- |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| His | Arg | Ile | Phe | Leu | Ala | Gly | Asp | Lys | Asp |
| 1   |     |     |     | 5   |     |     |     |     | 10  |
- (2) INFORMATION FOR SEQ ID NO: 43:
- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 20 Ara h I position 551-560.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable



- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 43:

Ile Asp Gln Ile Glu Lys Gln Ala Lys Asp  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 44:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

- (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 21 Ara h I position 559-568.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE:

(viii) POSITION IN GENOME:

261

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable
- (C) UNITS: Not applicable

## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 44:

Lys Asp Leu Ala Phe Pro Gly Ser Gly Glu  
1 5 10

## (2) INFORMATION FOR SEQ ID NO: 45:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids

- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 22 Ara h I position 578-587.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:

- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 45:

Lys	Glu	Ser	His	Phe	Val	Ser	Ala	Arg	Pro
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 46:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h I IgE binding epitope peptide 23 Ara h I position 597-606.

- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:

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- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 46:  

Pro	Glu	Lys	Glu	Ser	Pro	Glu	Lys	Glu	Asp
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 47:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h II IgE binding epitope peptide 1 Ara h II position 14-23.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea

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- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:



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- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 47:  

Leu	Leu	Ala	Ala	His	Ala	Ser	Ala	Arg	Gln
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 48:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 10 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as Ara h II IgE binding epitope peptide 2 Ara h II position 27-36.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h I
    - (D) DEVELOPMENT STAGE:
    - (E) HAPLOTYPE: Not applicable
    - (F) TISSUE TYPE:

- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:

## (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 48:

Gln Gly Asp Arg Arg Cys Gln Ser Gln Leu  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 49:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h II IgE binding epitope peptide 3 Ara h II position 60-69.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable

(vi) ORIGINAL SOURCE:

(A) ORGANISM: Arachis hypogaea

(B) STRAIN: Florunner

(C) INDIVIDUAL ISOLATE: Ara h I

(D) DEVELOPMENT STAGE:

(E) HAPLOTYPE: Not applicable

(F) TISSUE TYPE:

(G) CELL TYPE: Not applicable

(H) CELL LINE: Not applicable

(I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

(A) LIBRARY:

(B) CLONE:

(viii) POSITION IN GENOME:

(A) CHROMOSOME: Not applicable

(B) MAP POSITION: Not applicable

(C) UNITS: Not applicable

(ix) FEATURE:

(A) NAME/KEY:

(B) LOCATION:

(C) IDENTIFICATION METHOD: By agreement with  
protein information and established  
consensus sequence

(D) OTHER INFORMATION: Seed storage protein and  
allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 49:

Tyr Glu Arg Asp Pro Tyr Ser Pro Ser Gln  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 50:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 10 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: Not applicable
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h II IgE binding epitope peptide 4 Ara h II position 81-90.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable

- (ix) FEATURE:
- (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 50:

Ala Gly Ser Ser Gln His Gln Glu Arg Cys  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 51:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

- (ii) MOLECULE TYPE: glycoprotein
  - (A) DESCRIPTION: identified as Ara h II IgE binding epitope peptide 5 Ara h II position 91-100.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h I
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE:
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence

(D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 51:

Cys Asn Glu Leu Asn Glu Phe Glu Asn Asn  
1 5 10

(2) INFORMATION FOR SEQ ID NO: 52:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: glycoprotein

(A) DESCRIPTION: identified as Ara h II IgE binding epitope peptide 6 Ara h II position 105-159.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not applicable



## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: *Arachis hypogaea*
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE:

## (viii) POSITION IN GENOME:

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable
- (C) UNITS: Not applicable

## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:

- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 52:  

Gln	Arg	Cys	Asp	Leu	Asp	Val	Glu	Ser	Gly
1				5					10
- (2) INFORMATION FOR SEQ ID NO: 53:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 28 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: glycoprotein
    - (A) DESCRIPTION: identified as derived N-terminal sequence of Ara h 2 p38.
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: N-terminal fragment
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: P38
    - (D) DEVELOPMENT STAGE:

- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:

- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 53:

Gln	Gln	Trp	Glu	Leu	Gln	Gly	Asp	Arg	Arg	
1				5					10	
Cys	Gln	Ser	Gln	Leu	Glu	Arg	Ala	Asn	Leu	
				15					20	
Arg	Pro	Cys	Glu	Gln	His	Leu	Met			
				25						

(2) INFORMATION FOR SEQ ID NO: 54:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 13 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

- (A) DESCRIPTION: identified as peptide 45 of Ara h 2 p38.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: amino terminus

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: P38
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable

- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:

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(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 54:

Ala	Asn	Leu	Arg	Pro	Cys	Glu	Gln	His	Leu	Met	Gln	Lys
1				5					10			

(2) INFORMATION FOR SEQ ID NO: 55:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 17 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

- (A) DESCRIPTION: identified as peptide 37 of Ara h 2 p38.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: amino terminus

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: P38
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE: P38

## (viii) POSITION IN GENOME:

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable
- (C) UNITS: Not applicable

## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 55:

Asp Pro Tyr Ser Pro Ser Gln Asp Pro Tyr Ser Pro  
1 5 10  
Ser Pro Tyr Asp Arg  
15

## (2) INFORMATION FOR SEQ ID NO: 56:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 8 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: Not applicable
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: peptide
  - (A) DESCRIPTION: identified as peptide 20 of Ara h 2 p38.
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: amino terminus
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: P38
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable



## (ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 56:

Gln Gln Glu Gln Gln Phe Lys Arg  
1 5

## (2) INFORMATION FOR SEQ ID NO: 57:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 30 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

- (ii) MOLECULE TYPE: peptide
  - (A) DESCRIPTION: identified as 17.5 kD N-terminal peptide sequence of Ara h 2 p38 (gene sequence 19..48).
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: amino terminus
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: P38
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established

285

consensus sequence

(D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

(A) AUTHORS:

(B) TITLE:

(C) JOURNAL:

(D) VOLUME:

(E) ISSUE:

(F) PAGES:

(G) DATE:

(H) DOCUMENT NUMBER:

(I) FILING DATE:

(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 57:

Gly	Gln	Gln	Trp	Glu	Leu	Gln	Gly	Asp	Arg	Arg	Arg	Gln
1				5					10			
Ser	Gln	Leu	Glu	Arg	Ala	Asn	Leu	Xaa	Pro	Xaa	Glu	Gln
	15					20					25	
Xaa	Leu	Met	Xaa									
			30									

(2) INFORMATION FOR SEQ ID NO: 58:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 28 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(A) DESCRIPTION: identified as 17.5 kD N-terminal sequence of Ara h 2 p38 (gene sequence 20..47).

- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: amino terminus
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: P38
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 58:

Gln	Gln	Trp	Glu	Leu	Gln	Gly	Asp	Arg	Arg	Arg	Gln	Ser
1				5					10			
Gln	Leu	Glu	Arg	Ala	Asn	Leu	Arg	Pro	Cys	Glu	Gln	His
15					20					25		
Lys	Met											

(2) INFORMATION FOR SEQ ID NO: 59:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 8 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

- (A) DESCRIPTION: identified as peptide 20  
of Ara h 2 p38 (gene sequence 121..128).

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: amino terminus

- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: *Arachis hypogaea*
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II p38
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:

- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 59:  
Gln Gln Glu Gln Gln Phe Lys Arg  
1 5
- (2) INFORMATION FOR SEQ ID NO: 60:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 8 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: peptide
    - (A) DESCRIPTION: identified as Ara h 2 p38 peptide 20 (gene sequence 121..128).
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: Not applicable
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: Ara h II p38
    - (D) DEVELOPMENT STAGE:

- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:



- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 60:  
Gln Gln Glu Gln Gln Phe Lys Arg  
1 5
- (2) INFORMATION FOR SEQ ID NO: 61:
  - (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 17 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: peptide
    - (A) DESCRIPTION: identified as Ara h 2 p38 peptide 37 (gene sequence 60-76).
  - (iii) HYPOTHETICAL: No
  - (iv) ANTI-SENSE: Not applicable
  - (v) FRAGMENT TYPE: amino terminus
  - (vi) ORIGINAL SOURCE:
    - (A) ORGANISM: Arachis hypogaea
    - (B) STRAIN: Florunner
    - (C) INDIVIDUAL ISOLATE: P38
    - (D) DEVELOPMENT STAGE:
    - (E) HAPLOTYPE: Not applicable
    - (F) TISSUE TYPE:
    - (G) CELL TYPE: Not applicable
    - (H) CELL LINE: Not applicable
    - (I) ORGANELLE: Not applicable

- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 61:  
Asp Pro Tyr Ser Pro Ser Gln Asp Pro Tyr Ser Pro Ser

293

1  
Pro Tyr Asp Arg  
15

5

10

## (2) INFORMATION FOR SEQ ID NO: 62:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 17 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

## (ii) MOLECULE TYPE: peptide

- (A) DESCRIPTION: identified as Ara h 2 p38 peptide 37 (gene sequence 60-76).

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: Not applicable

## (v) FRAGMENT TYPE: Not Applicable

## (vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h II P38
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE:
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable

## (vii) IMMEDIATE SOURCE:

- (A) LIBRARY:
- (B) CLONE: P38

## (viii) POSITION IN GENOME:

- (A) CHROMOSOME: Not applicable
- (B) MAP POSITION: Not applicable
- (C) UNITS: Not applicable

(ix) FEATURE:

- (A) NAME/KEY:
- (B) LOCATION:
- (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
- (D) OTHER INFORMATION: Seed storage protein and allergen

(x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 62:

Asp Pro Tyr Ser Pro Ser Gln Asp Pro Tyr  
1 5 10  
Ser Pro Ser Pro Tyr Asp Arg  
15

(2) INFORMATION FOR SEQ ID NO: 63:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 13 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: peptide
  - (A) DESCRIPTION: identified as Ara h 2 p38 peptide 45 (gene sequence 37-49).
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not Applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II P38
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:

- (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
- (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 63:
- |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ala | Asn | Leu | Arg | Pro | Cys | Glu | Gln | His | Leu | Met | Gln | Lys |
| 1   |     |     |     | 5   |     |     |     |     | 10  |     |     |     |
- (2) INFORMATION FOR SEQ ID NO: 64:
- (i) SEQUENCE CHARACTERISTICS:
    - (A) LENGTH: 13 amino acids
    - (B) TYPE: amino acid
    - (C) STRANDEDNESS: Not applicable
    - (D) TOPOLOGY: unknown
  - (ii) MOLECULE TYPE: peptide

- (A) DESCRIPTION: identified as Ara h 2 peptide 45 (gene sequence 37-49).
- (iii) HYPOTHETICAL: No
- (iv) ANTI-SENSE: Not applicable
- (v) FRAGMENT TYPE: Not Applicable
- (vi) ORIGINAL SOURCE:
  - (A) ORGANISM: Arachis hypogaea
  - (B) STRAIN: Florunner
  - (C) INDIVIDUAL ISOLATE: Ara h II P38
  - (D) DEVELOPMENT STAGE:
  - (E) HAPLOTYPE: Not applicable
  - (F) TISSUE TYPE:
  - (G) CELL TYPE: Not applicable
  - (H) CELL LINE: Not applicable
  - (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and

allergen

## (x) PUBLICATION INFORMATION:

- (A) AUTHORS:
- (B) TITLE:
- (C) JOURNAL:
- (D) VOLUME:
- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 64:

Ala	Asn	Leu	Arg	Pro	Cys	Glu	Gln	His	Leu	Met	Gln	Lys
1				5					10			

## (2) INFORMATION FOR SEQ ID NO: 65:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 16 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

## (ii) MOLECULE TYPE: peptide

- (A) DESCRIPTION: identified as Ara h I peptide I.

## (iii) HYPOTHETICAL: No

## (iv) ANTI-SENSE: Not applicable

## (v) FRAGMENT TYPE: Not Applicable

## (vi) ORIGINAL SOURCE:



- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable
- (F) TISSUE TYPE: cDNA
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:

- (E) ISSUE:
- (F) PAGES:
- (G) DATE:
- (H) DOCUMENT NUMBER:
- (I) FILING DATE:
- (J) PUBLICATION DATE:
- (K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 65:

Ile	Phe	Leu	Ala	Gly	Asp	Lys	Asp	Asn	Val	Ile
1				5					10	
Asp	Gln	Ile	Glu	Lys						
			15							

(2) INFORMATION FOR SEQ ID NO: 66:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 16 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: Not applicable
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(A) DESCRIPTION: identified as Ara h I peptide II.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not Applicable

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: Arachis hypogaea
- (B) STRAIN: Florunner
- (C) INDIVIDUAL ISOLATE: Ara h I
- (D) DEVELOPMENT STAGE:
- (E) HAPLOTYPE: Not applicable

- (F) TISSUE TYPE: cDNA
- (G) CELL TYPE: Not applicable
- (H) CELL LINE: Not applicable
- (I) ORGANELLE: Not applicable
- (vii) IMMEDIATE SOURCE:
  - (A) LIBRARY:
  - (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:

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(J) PUBLICATION DATE:

(K) RELEVANT RESIDUES:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 66:

Lys	Gly	Ser	Glu	Glu	Glu	Gly	Asp	Ile	Thr
1				5					10
Asn	Pro	Ile	Asn	Leu	Arg				
			15						

(2) INFORMATION FOR SEQ ID NO: 67:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: Not applicable

(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(A) DESCRIPTION: identified as Ara h I peptide III.

(iii) HYPOTHETICAL: No

(iv) ANTI-SENSE: Not applicable

(v) FRAGMENT TYPE: Not Applicable

(vi) ORIGINAL SOURCE:

(A) ORGANISM: Arachis hypogaea

(B) STRAIN: Florunner

(C) INDIVIDUAL ISOLATE: Ara h I

(D) DEVELOPMENT STAGE:

(E) HAPLOTYPE: Not applicable

(F) TISSUE TYPE: cDNA

(G) CELL TYPE: Not applicable

(H) CELL LINE: Not applicable

(I) ORGANELLE: Not applicable

(vii) IMMEDIATE SOURCE:

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- (A) LIBRARY:
- (B) CLONE: P38
- (viii) POSITION IN GENOME:
  - (A) CHROMOSOME: Not applicable
  - (B) MAP POSITION: Not applicable
  - (C) UNITS: Not applicable
- (ix) FEATURE:
  - (A) NAME/KEY:
  - (B) LOCATION:
  - (C) IDENTIFICATION METHOD: By agreement with protein information and established consensus sequence
  - (D) OTHER INFORMATION: Seed storage protein and allergen
- (x) PUBLICATION INFORMATION:
  - (A) AUTHORS:
  - (B) TITLE:
  - (C) JOURNAL:
  - (D) VOLUME:
  - (E) ISSUE:
  - (F) PAGES:
  - (G) DATE:
  - (H) DOCUMENT NUMBER:
  - (I) FILING DATE:
  - (J) PUBLICATION DATE:
  - (K) RELEVANT RESIDUES:
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 67:  
Asn Asn Pro Phe Tyr Phe Pro Ser Arg Arg  
1 5 10

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Thus, it will be appreciated that as a result of the present invention, a highly effective improved immunization or vaccination therapy, immunoassay, amino acid or DNA sequence, peanut allergens, antibodies, cell lines, treatment  
5 compositions, and methods are provided by which the principal objective, among others is completely fulfilled. It is contemplated, and will be apparent to those skilled in the art from the preceding description and accompanying drawings, that modifications and/or changes may be made in the illustrated  
10 embodiments without departure from the present invention. Accordingly, it is expressly intended that the foregoing description and accompanying drawings are illustrative of preferred embodiments only, not limiting, and that the true spirit and scope of the present invention be determined by  
15 reference to the appended claims.

## CLAIMS

What is claimed as invention is:

- 1 1. An isolated and purified peanut allergen designated Ara h  
2 I and having a mean molecular weight of 63.5 kD and a mean  
3 isoelectric point of 4.55.
- 1 2. An antigen comprising the allergen of claim 1.
- 1 3. An isolated and purified peanut allergen designated Ara h  
2 II and having a mean molecular weight of 17 kD as determined by  
3 IgE-specific immunoblotting and a mean isoelectric point of 5.2  
4 as determined by two-dimensional gel electrophoresis.
- 1 4. An antigen comprising the allergen of claim 3.
- 1 5. The antigen of claim 4 having an initial nine amino acid  
2 N-terminus sequence of (\*)-Q-Q-(\*)-E-L-Q-D-L.
- 1 6. The antigen of claim 5 having the amino acid sequence  
2 shown in Table 12.
- 1 7. A monoclonal antibody having an antigen combining site  
2 which binds to the peanut allergen antigen of claim 2 and which  
3 is capable of functioning as at least one of two monoclonal  
4 antibodies in a two-site monoclonal antibody based enzyme-  
5 linked immunosorbent assay for peanut allergen.
- 1 8. A monoclonal antibody having an antigen combining site  
2 which binds to the peanut allergen antigen of claim 4.

1 9. A hybridoma cell line capable of producing antibodies for  
2 use in a two-site monoclonal antibody based enzyme-linked  
3 immunosorbent assay for the peanut allergen of claim 1 and  
4 antibody producing reclones thereof.

1 10. A hybridoma cell line capable of producing antibodies for  
2 the peanut allergen of claim 3 and antibody producing reclones  
3 thereof.

1 11. A method of producing peanut allergen binding monoclonal  
2 antibodies for use in a two-site monoclonal antibody enzyme-  
3 linked immunosorbent assay comprising immunizing an animal with  
4 the peanut allergen of claim 1, forming fused cell hybrids  
5 between antibody producing cells from said animal and myeloma  
6 cells, cloning said hybrids and selecting clones which produce  
7 antibodies that demonstrate specificity for the peanut  
8 allergen.

1 12. In an immunoassay for peanut allergen, the improvement  
2 comprising a monoclonal antibody being derived from a hybridoma  
3 and demonstrating specificity for a binding site of the peanut  
4 allergen antigen of claim 4.

1 13. A method for at least detecting the presence of the peanut  
2 allergen Ara h I in a sample using a two-site monoclonal  
3 antibody enzyme-linked immunosorbent assay comprising the steps  
4 of:



coating an assay test surface with a layer of capture monoclonal antibodies having a specificity for the Ara h II allergen,

incubating the coated test surface to allow the capture monoclonal antibodies to adhere to the test surface,

washing the coated test surface to remove any unadhered capture monoclonal antibodies,

adding a sample to the coated test surface,

incubating the coated test surface to allow the adhered capture monoclonal antibodies to capture any Ara h II peanut allergen present in the sample, washing the coated test surface to remove the uncaptured peanut allergen and remaining sample,

adding a layer of biotinylated monoclonal antibodies having a specificity for the Ara h II allergen to the coated test surface,

incubating the coated test surface to allow the biotinylated monoclonal antibodies to bind to the captured peanut allergen,

washing the coated test surface to remove unbound biotinylated monoclonal antibodies,

adding horseradish peroxidase-avidin conjugate to the coated test surface,

allowing the horseradish-peroxidase, avidin conjugate to bind to the biotinylated monoclonal antibodies,

washing the coated test surface to remove any unbound horseradish peroxidase-avidin conjugate,

adding citric acid substrate to the coated test surface to develop a color change indicative of the quantity of bound horseradish peroxidase,

34 adding a stopping agent to stop the development of the  
35 color change, and  
36 reading the assay to determine at least the presence of the  
37 peanut allergen Ara h II.

1 14. The method as recited in claim 13 wherein the capture  
2 monoclonal antibody and biotinylated monoclonal antibody  
3 demonstrate specificity for different binding sites on the  
4 peanut allergen Ara h II.

1 15. A method of producing peanut allergen binding monoclonal  
2 antibodies for use in a two-site monoclonal antibody enzyme-  
3 linked immunosorbent assay comprising immunizing an animal with  
4 the peanut allergen of claim 13, forming fused cell hybrids  
5 between antibody producing cells from said animal and myeloma  
6 cells, cloning said hybrids and selecting clones which produce  
7 antibodies that demonstrate specificity for the peanut  
8 allergen.

1 16. An antigen for producing murine monoclonal antibodies  
2 having specificity for a selected peanut allergen comprising an  
3 isolated and purified peanut allergen designated Ara h I and  
4 having a mean molecular weight of 63.5 kD and a mean  
5 isoelectric point of 4.55.

1 17. An antigen for producing murine monoclonal antibodies  
2 having specificity for the Ara h II allergen of claim 3.

1 18. The antigen of claim 4 having the upper band amino acid  
2 sequence shown in Table 12.

1 19. The antigen of claim 4 having the lower band amino acid  
2 sequence shown in Table 12.

1 20. The allergen of claim 3 having at least one of the upper  
2 and lower band amino acid sequences shown in Table 12.

1 21. A murine monoclonal antibody antigen for producing murine  
2 monoclonal antibodies having specificity for a selected peanut  
3 allergen comprising an isolated and purified peanut allergen  
4 designated Ara h I and having a mean molecular weight of 63.5  
5 kD and a mean isoelectric point of 4.55.

1 22. The allergen of claim 3 having an initial nine amino acid  
2 N-terminus sequence of (\*)-Q-Q-(\*)-E-L-Q-D-L (SEQ ID NO:3).

3 23. The allergen of claim 3 with an amino acid N-terminus  
4 sequence having the upper band amino acid sequence shown in  
5 Table 12 (SEQ ID NO:1).

1 24. The allergen of claim 3 with an amino acid N-terminus  
2 sequence having the lower band amino acid sequence shown in  
3 Table 12 (SEQ ID NO:2).

1 25. The allergen of claim 3 having at least one of the N-  
2 terminus sequences of SEQ ID NO:1 and SEQ ID NO:2.

1 26. A murine monoclonal antibody having an antigen combining  
2 site which binds to a peanut allergen Ara h I comprised of a  
3 protein fraction having a mean molecular weight of 63.5 kD and  
4 a mean isoelectric point of 4.55, and for functioning as at  
5 least one of two monoclonal antibodies in a two-site monoclonal  
6 antibody based enzyme-linked immunosorbent assay for detecting  
7 said peanut allergen Ara h I in a sample.

1 27. A murine monoclonal antibody pair for use in a two-site  
2 monoclonal antibody based enzyme-linked immunosorbent assay for  
3 detecting a peanut allergen Ara h I in a sample, each of said  
4 monoclonal antibodies of said pair bonding to a different  
5 epitope of said peanut allergen Ara h I comprised of a protein  
6 fraction having a mean molecular weight of 63.5 kD and a mean  
7 isoelectric point of 4.55.

1 28. A hybridoma cell line for producing murine monoclonal  
2 antibodies for use in a two-site monoclonal antibody based  
3 enzyme-linked immunosorbent assay for detecting a peanut  
4 allergen Ara h I in a sample and having specificity for said  
5 peanut allergen Ara h I comprised of a protein fraction having  
6 a mean molecular weight of 63.5 kD and a mean isoelectric point  
7 of 4.55, and antibody producing reclones thereof.

1 29. A method of producing peanut allergen Ara h I binding  
2 murine monoclonal antibodies for use in a two-site monoclonal  
3 antibody enzyme-linked immunosorbent assay for detecting said  
4 peanut allergen Ara h I in a sample comprising immunizing an  
5 animal with said peanut allergen Ara h I comprised of a protein

6 fraction having a mean molecular weight of 63.5 kD and a mean  
7 isoelectric point of 4.55, forming fused cell hybrids between  
8 antibody producing cells from said animal and myeloma cells,  
9 cloning said hybrids and selecting clones which produce  
10 antibodies that demonstrate specificity for said peanut  
11 allergen Ara h I.

1 30. An antigen having the sequence shown in at least one of  
2 Tables 1-36, Figures 1-34, and sequence listing sequence id  
3 nos. 1-67.

1 31. A sequence having the sequence shown in at least one of  
2 Tables 1-36, Figures 1-34, and sequence listing sequence id  
3 nos. 1-67.

1 32. A method of treating humans comprising the steps of  
2 isolating and identifying a protein or epitope binding IgE,  
3 mutating the protein or epitope so that it no longer binds IgE,  
4 vaccinating a patient with the mutated protein or epitope.



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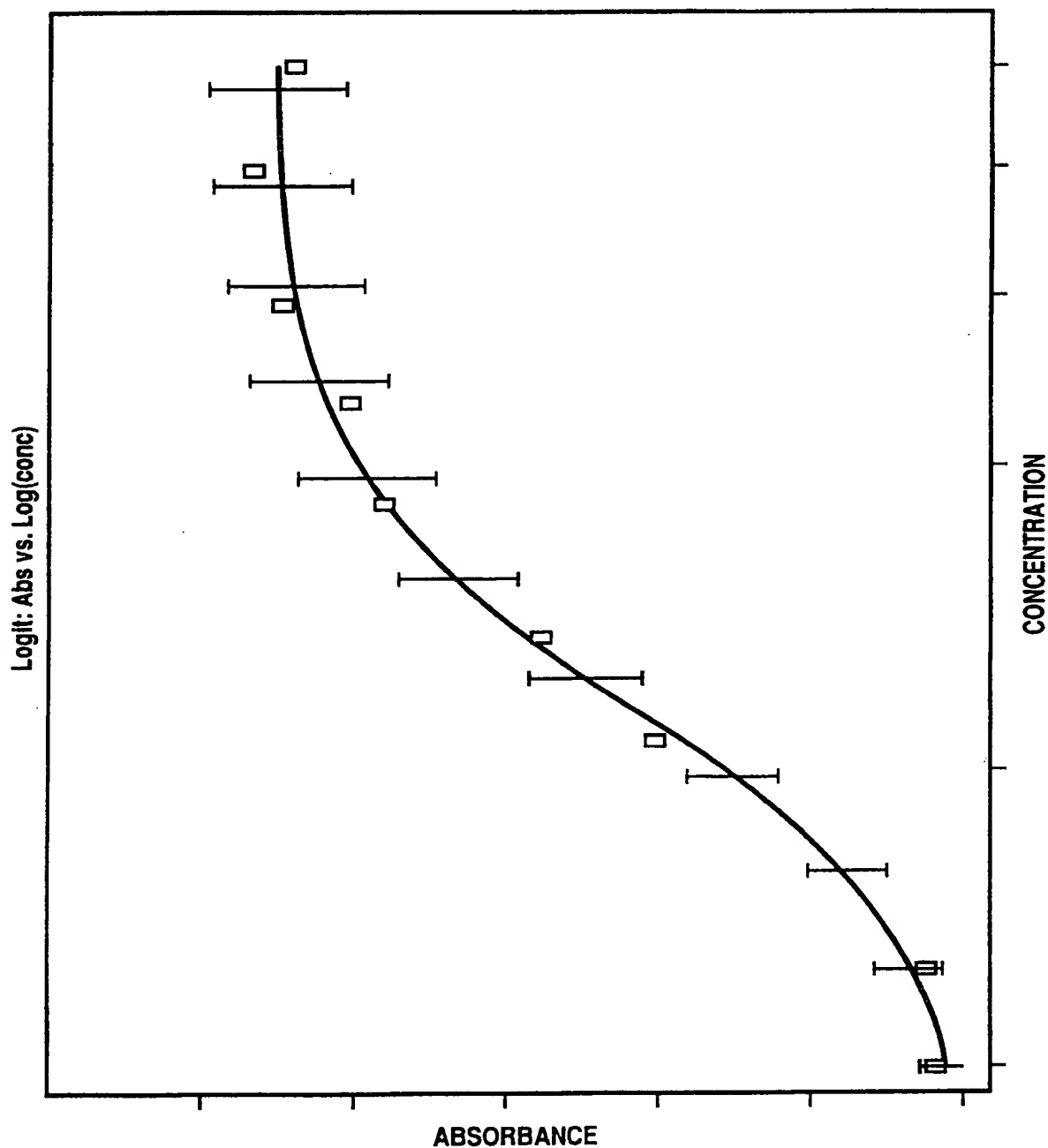


Fig.1





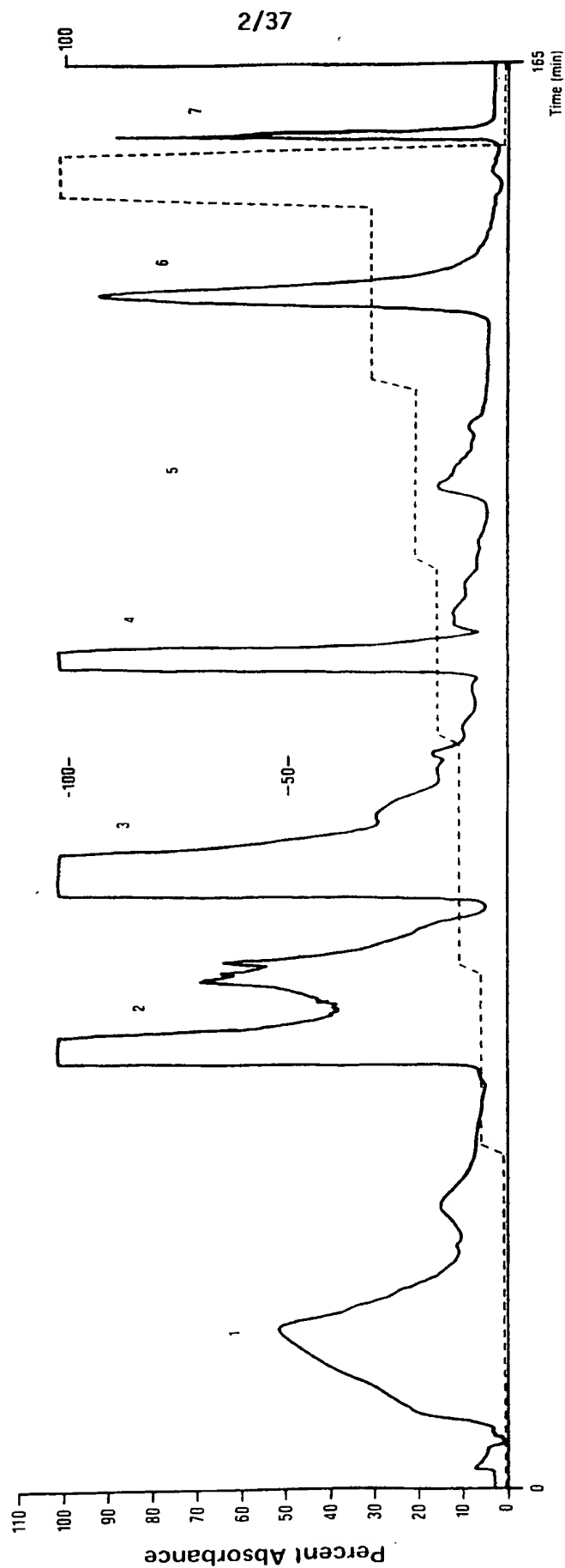


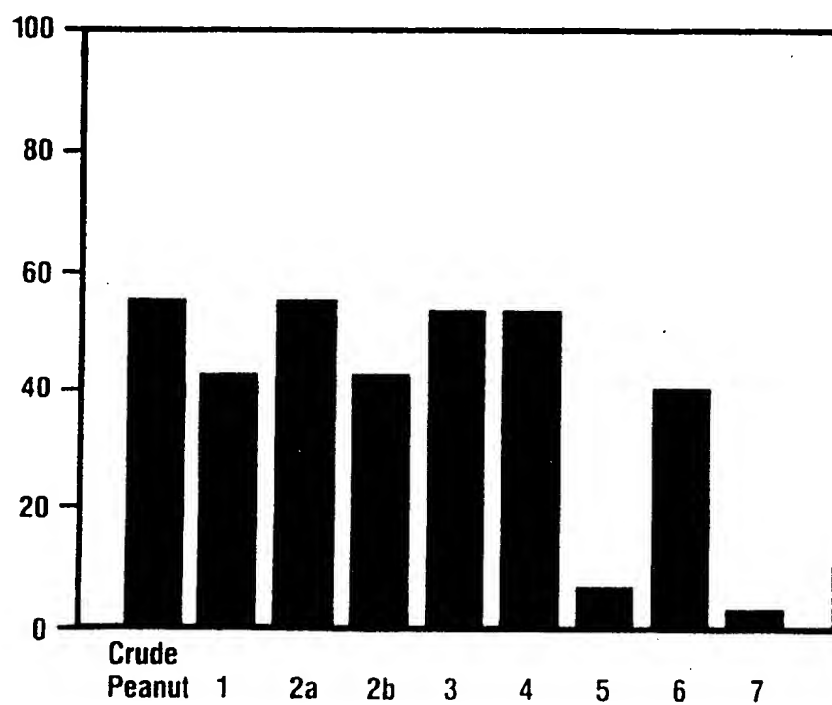
FIG. 2



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**ELISA**

anti-peanut IgE (ng/ml)

**FIG. 3**



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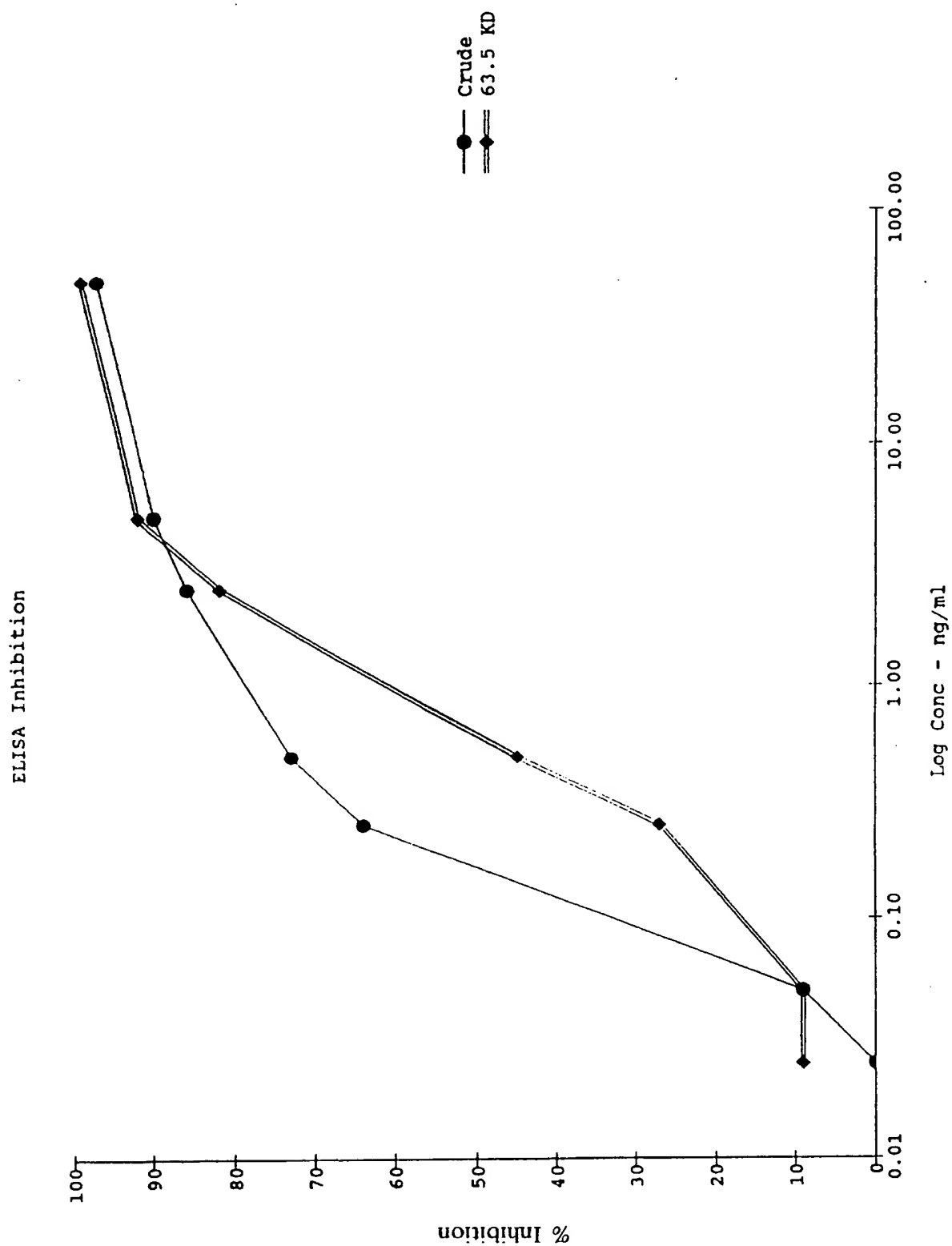
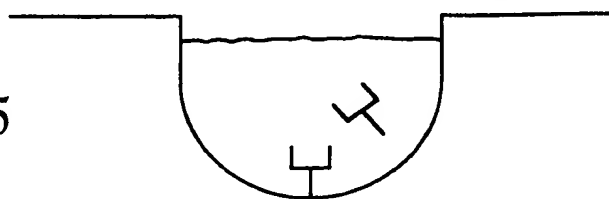


FIG. 4



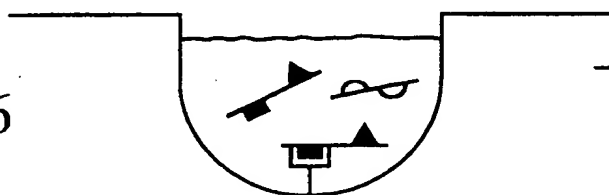
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Fig.5



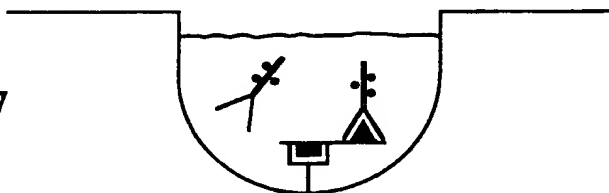
Y — CAPTURE MAb

Fig.6



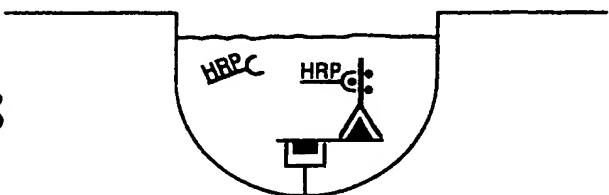
— PEANUT ALLERGEN  
 — EPI TOPE #1  
 — EPI TOPE #2  
 — UNKNOWN

Fig.7



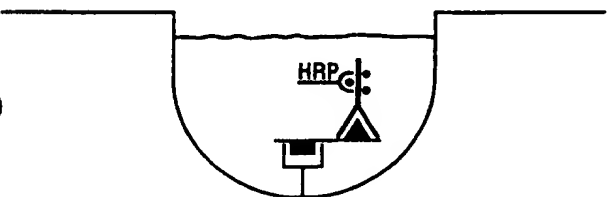
— BIOTINYLATED MAb  
 • — BIOTIN  
 — MAb

Fig.8



— HRP-AVIDIN  
 C — AVIDIN  
 HRP — HORSERADISH PEROXIDASE

Fig.9



HRP + SUBSTRATE  $\Rightarrow$  COLOR  
 CHANGE READ @  $\approx$  490 nm





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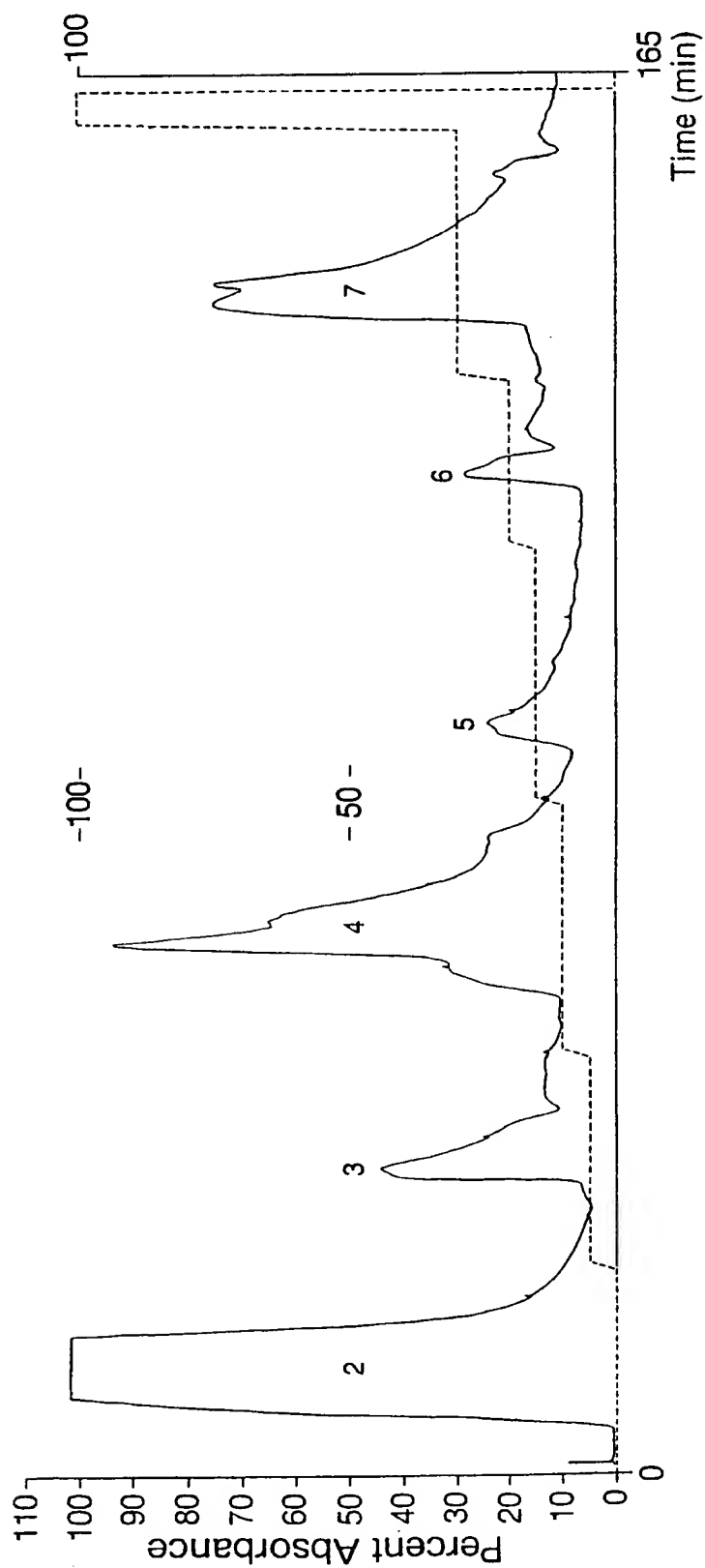
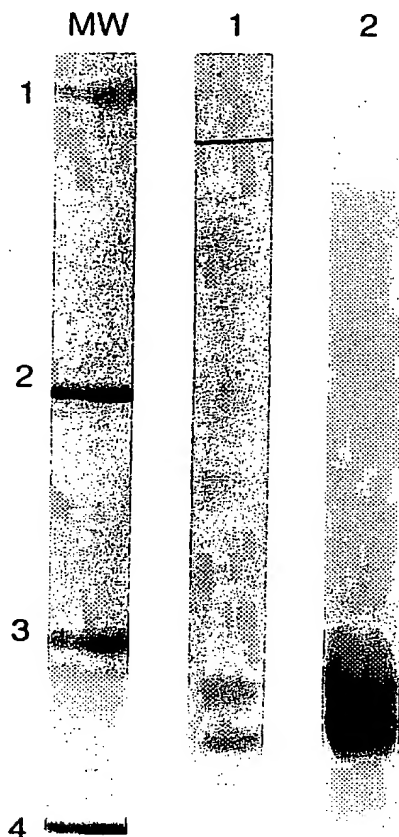


FIG. 10



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**FIG. 11** SDS-PAGE (14 cm x 12 cm) analysis of the defatted crude peanut extract stained with Coomassie brilliant blue (lane 1) and immunoblotted for anti-peanut specific IgE (lane 2) with pooled serum from patients with AD and positive DBPCFCs to peanut. Molecular weights: 1, 50,000; 2, 39,000; 3, 27,500; 4, 14,500.



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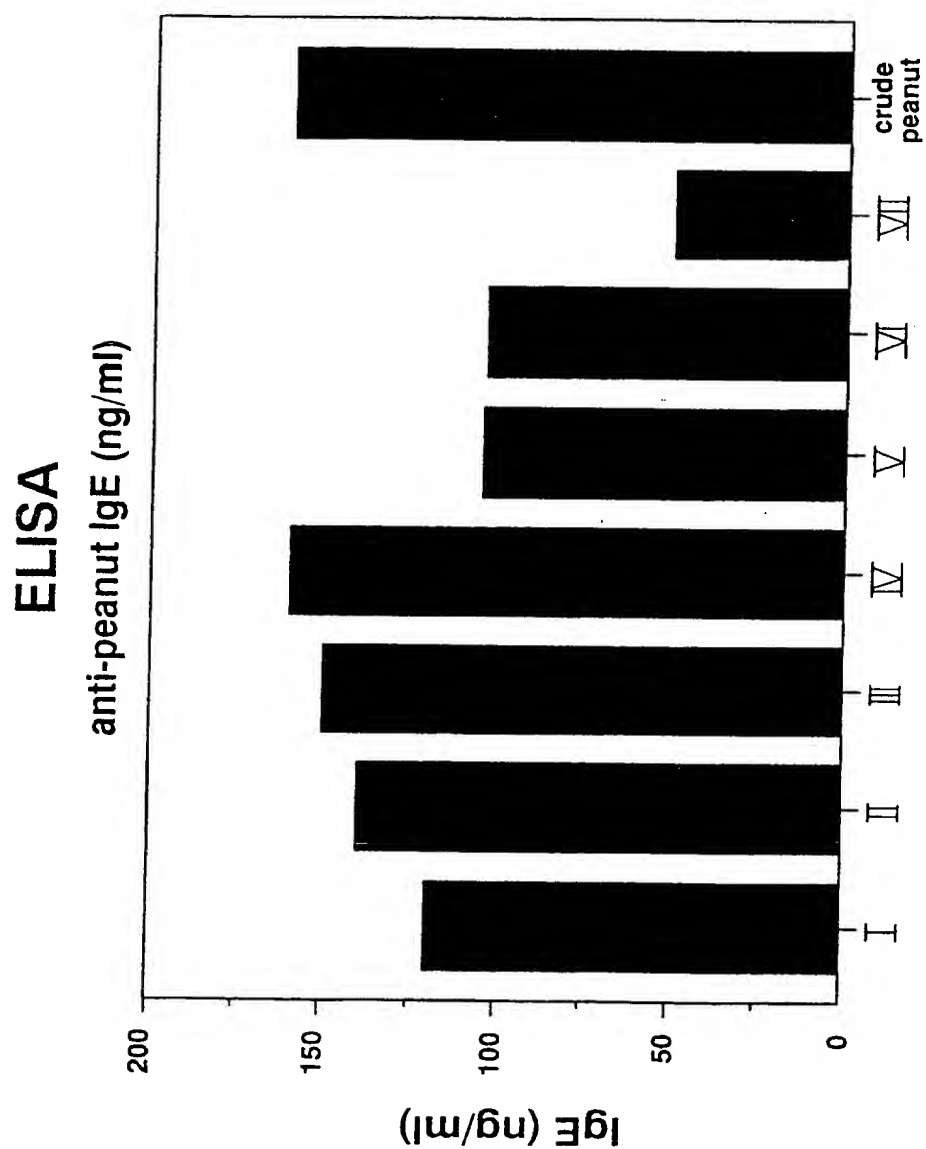


FIG. 12



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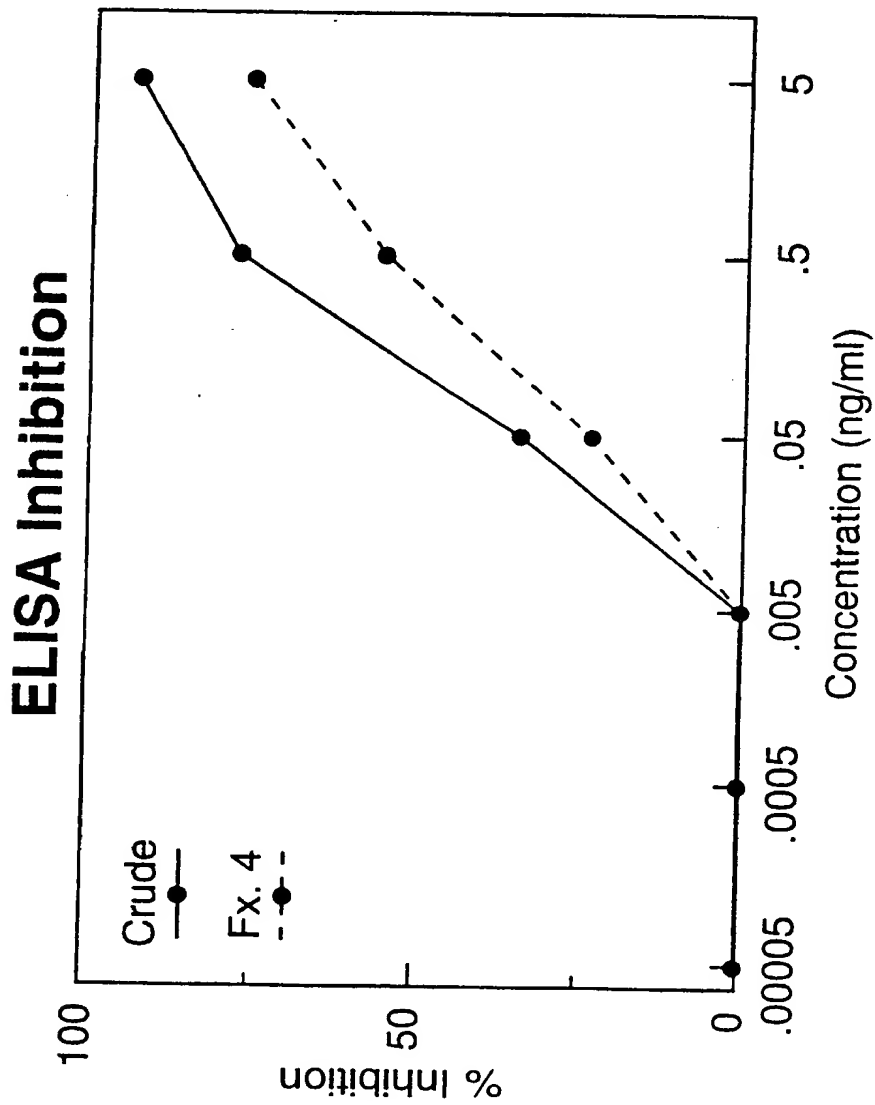


FIG. 13

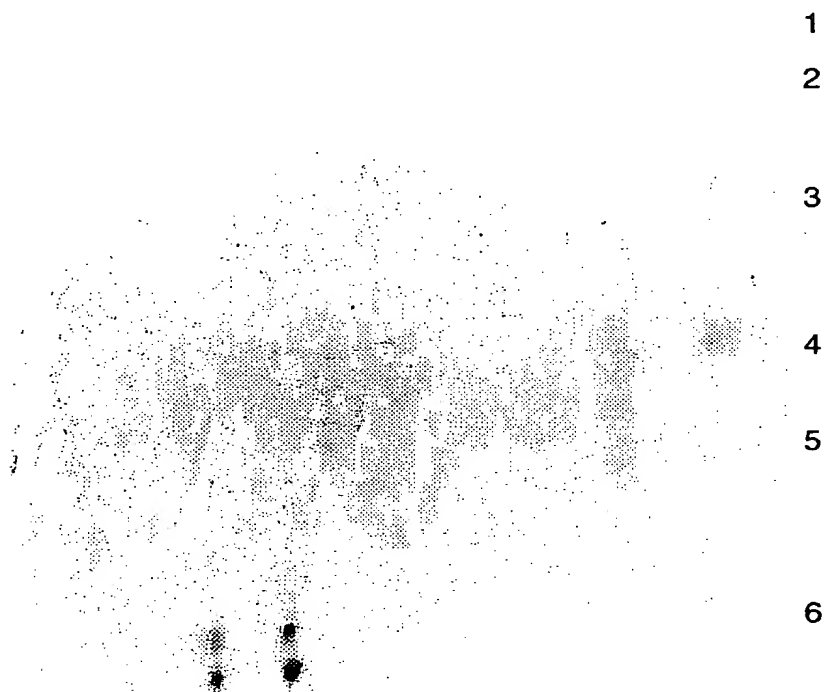




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(-)

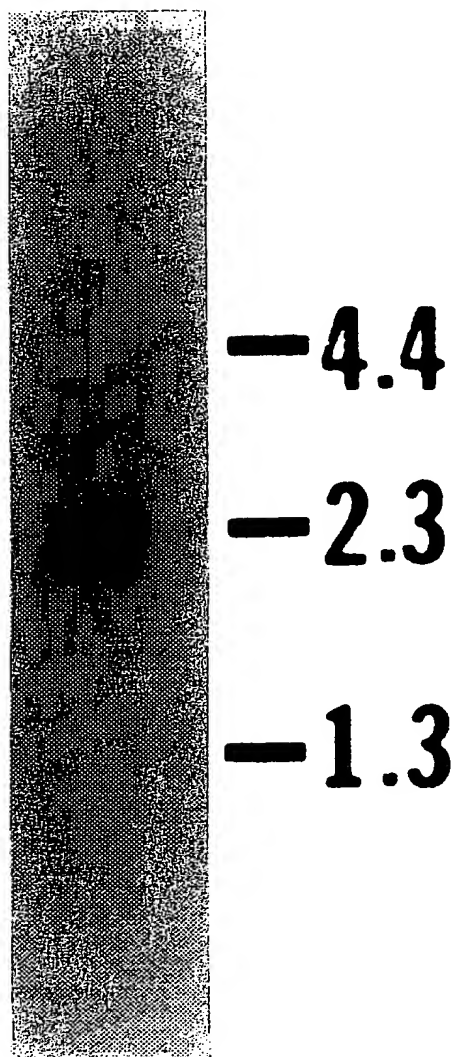
(+) MW



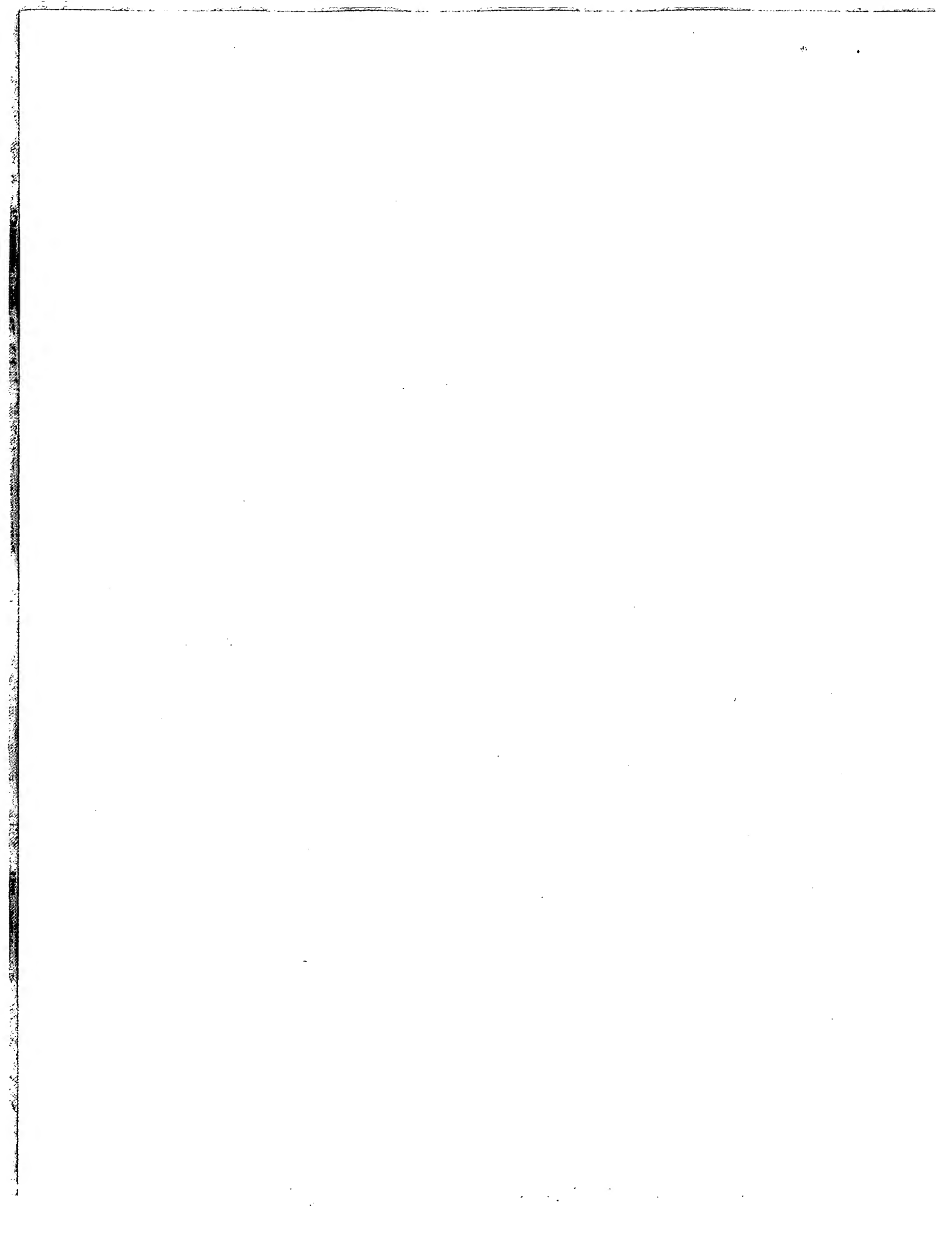
**FIG14** Coomassie brilliant blue stain of two-dimensional gel with fraction 4 (anion exchange column) containing the 17 kd allergen. Molecular weights: 1, 112,000; 2, 75,000; 3, 50,000; 4, 39,000; 5, 27,500; 6, 17,000.



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**FIGURE 15**

An *Ara h I* clone hybridizes to a 2.3-kb peanut mRNA. Peanut poly (A)<sup>+</sup> RNA was isolated from *Arachis hypogaea* (Florunner) species and 10  $\mu$ g were electrophoresed on denaturing formaldehyde agarose gels. Insert from 41B was purified, labeled with alpha-<sup>32</sup>P-dCTP, and used as a hybridization probe of a Northern blot of this gel. Sizes of known RNA species are expressed in kilobases along the right side of the figure.



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1     AATAATCATATATATTCATCAATCATCTATATAAGTAGTAGCAGGAGCA  
-----..

50     ATGAGAGGGAGGGTTTCTCCACTGATGCTGTTGCTAGGGATCCTTGTCTTG  
.....

      M R G R V S P L M L L L G I L V L   17

101    GCTTCAGTTTCTGCAACGCATGCCAAGTCATCACCTTACCAGAAGAAAAC  
.....G.....C.-----TT.CCG.....

      A S V S A T H A K S S P Y Q K K T   34

151    AGAGAACCCCTGCGCCCAGAGGTGCCTCCAGAGTTGTCAACAGGAACCGG  
.....

      E N P C A Q R C L Q S C Q Q E P   50

201    ATGACTTGAAGCAAAAGGCATGCGAGTCTCGCTGCACCAAGCTCGAGTAT  
.....

      D D L K Q K A C E S R C T K L E Y   67

251    GATCCTCGTTGTGTCTATGATCCTCGAGGACACACTGGCACCACCAACCA  
.....G.....

      D P R C V Y D P R G H T G T T N Q   84

301    ACGTTCCCCTCCAGGGGAGCGGACACGTGGCCGCCAACCCGGAGACTACG  
....CA.....

      R S P P G E R T R G R Q P G D Y   100

351    ATGATGACCGCCGTCAACCCCGAAGAGAGGAAGGAGGCCGATGGGGACCA  
.....

      D D D R R Q P R R E E G G R W G P   117

401    GCTGGACCGAGGGAGCGTGAAAGAGAAGAAGACTGGAGACAACCAAGAGA  
....A.....

      A G P R E R E R E E D W R Q P R E   134

FIGURE 16A



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451 AGATTGGAGGCGACCAAGTCATCAGCAGCCACGGAAAATAAGGCCCCGAAG  
.....  
D W R R P S H Q Q P R K I R P E 150

501 GAAGAGAAGGAGAACAAGAGTGGGGAACACCAGGTAGCCATGTGAGGGAA  
.....G.G.....  
G R E G E Q E W G T P G S H V R E 167

551 GAAACATCTCGGAACAACCCTTTCTACTTCCCGTCAAGGCGGTTTAGCAC  
.....A.....  
E T S R N N P F Y F P S R R F S T 184

601 CCGCTACGGGAACCAAAACGGTAGGATCCGGGTCCTGCAGAGGTTTGACC  
.....C.....  
R Y G N Q N G R I R V L Q R F D 200

651 AAAGGTCAAGGCAGTTTCAGAATCTCCAGAATCACCGTATTGTGCAGATC  
.....A.....  
Q R S R Q F Q N L Q N H R I V Q I 217

701 GAGGCCAAACCTAACACTCTTGTTCTTCCCAAGCACGCTGATGCTGATAA  
.....G.....  
E A K P N T L V L P K H A D A D N 234

751 CATCCTTGTTATCCAGCAAGGGCAAGCCACCGTGACCGTAGCAAATGGCA  
.....A.....  
I L V I Q Q G Q A T V T V A N G 250

801 ATAACAGAAAGAGCTTTAATCTTGACGAGGGCCATGCACTCAGAATCCCA  
.....  
N N R K S F N L D E G H A L R I P 267

851 TCCGGTTTCATTTCTTACATCTTGAACCGCCATGACAACCAGAACCTCAG  
.....T..A.....  
S G F I S Y I L N R H D N Q N L R 284

901 AGTAGCTAAAATCTCCATGCCCGTTAACACACCCGGCCAGTTTGAGGATT  
.....G.....  
A A K I S M P V N T P G Q F E D 300

FIGURE 16B





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951 TCTTCCCGGCGAGCAGCCGAGACCAATCATCCTACTTGCAGGGCTTCAGC  
.....A.....  
F F P A S S R D Q S S Y L Q G F S 317

1001 AGGAATACGTTGGAGGCCGCCTTCAATGCGGAATTCAATGAGATACGGAG  
.....T.....  
R N T L E A A F N A E F N E I R R 334

1051 GGTGCTGTTAGAAGAGAATGCAGGAGGTGAGCAAGAGGAGAGAGGGCAGA  
.....A.....  
V L L E E N A G G E Q E E R G Q 350

1101 GGCGATGGAGTACTCGGAGTAGTGAGAACAATGAAGGAGTGATAGTCAAA  
.....C.....---.T.....  
R R W S T R S S E N N E G V I V K 367

1151 GTGTCAAAGGAGCACGTTGAAGAACTTACTAAGCACGCTAAATCCGTCTC  
.....C.....  
V S K E H V E E L T K H A K S V S 384

1201 AAAGAAAGGCTCCGAAGAAGAGGGGAGATATCACCAACCCAATCAACTTGA  
.....A---.....  
K K G S E E E G D I T N P I N L 400

1251 GAGAAGGCGAGCCCGATCTTTCTAACAACCTTTGGGAAGTTATTTGAGGTG  
.....T.....G.....  
R E G E P D L S N N F G K L F E V 417

1301 AAGCCAGACAAGAAGAACCCCCAGCTTCAGGACCTGGACATGATGCTCAC  
.....  
K P D K K N P Q L Q D L D M M L T 434

1351 CTGTGTAGAGATCAAAGAAGGAGCTTTGATGCTCCACACTTCAACTCAA  
.....  
C V E I K E G A L M L P H F N S 450

FIGURE 16C



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1401 AGGCCATGGTTATCGTCGTCGTCACAAAGGAACTGGAAACCTTGAAGTC  
.....C.....  
K A M V I V V V N K G T G N L E L 467

1451 GTGGCTGTAAGAAAAGAGCAACAACAGAGGGGACGGCGGGAA-----  
..A.....CAAGAGTC  
V A V R K E Q Q Q R G R R E - - - 481

1493 -GAAGAGGAGGACGAAGACGAAGAAGAGGAGGGAAGTAACAGAGAGGTGC  
G.....A.....G.....T.....  
E E E D E D E E E E G S N R E V 497

1542 GTAGGTACACAGCGAGGTTGAAGGAAGGCGATGTGTTTCATCATGCCAGCA  
.....  
R R Y T A R L K E G D V F I M P A 514

1592 GCTCATCCAGTAGCCATCAACGCTTCCTCCGAACTCCATCTGCTTGGCTT  
.....  
A H P V A I N A S S E L H L L G F 531

1642 CGGTATCAACGCTGAAAACAACCACAGAATCTTCCTTGCAGGTGATAAGG  
.....  
G I N A E N N H R I F L A G D K 547

1692 ACAATGTGATAGACCAGATAGAGAAGCAAGCGAAGGATTTAGCATTCCCT  
.....  
D N V I D Q I E K Q A K D L A F P 564

1742 GGGTCGGGTGAACAAGTTGAGAAGCTCATCAAAAACCAGAAGGAATCTCA  
..T.....G...G.....  
G S G E Q V E K L I K N Q K E S H 581

1792 CTTTGTGAGTGCTCGTCCTCAATCTCAATCTCAATCTCCGTCGTCTCCTG  
.....CG..-----  
F V S A R P Q S Q S Q S P S S P 597

1842 AGAAAGAGTCTCCTGAGAAAGAGGATCAAGAGGAGGAAAACCAAGGAGGG  
-----A.....  
E K E S P E K E D Q E E E N Q G G 614

FIGURE 16D



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```

1892  AAGGTCCTCCCTTTCAATTTGAAGGCTTTAACTGAGAATGGAGGCA
      .....A.
      K G P L L S I L K A F N      626

1942  ACTTGTTATGTATCGATAATAAGATCAGCCTTTGTACTCTACTATCCAA
      .....C.....A.....

1992  AACTTATCAATAAAACGTTTGTGCGTTGTTCTCCAAAAAAA
      .....

```

Nucleotide sequence of an *Ara h 1* cDNA clone. The nucleotide sequence of clone 41B is shown on the first line. The second line depicts clone P17 DNA sequence with dots (.) representing nucleotides that are the same, dashes (-) nucleotides that are missing, and A, C, G, or T nucleotides that differ between the two DNA sequences. The protein synthesis start (ATG) and stop (TGA) sites are underlined along with a consensus polyadenylation signal (AATAAA). Bold amino acid residues are those areas which correspond to the determined amino acid sequence of peptides I, II, and III of *Ara h 1* (Table 14). The numbers on the left of the figure indicate the nucleotide sequence, and those on the right correspond to the deduced amino acid sequence. These sequence data are available from GenBank under accession number L34402.

FIGURE 16E



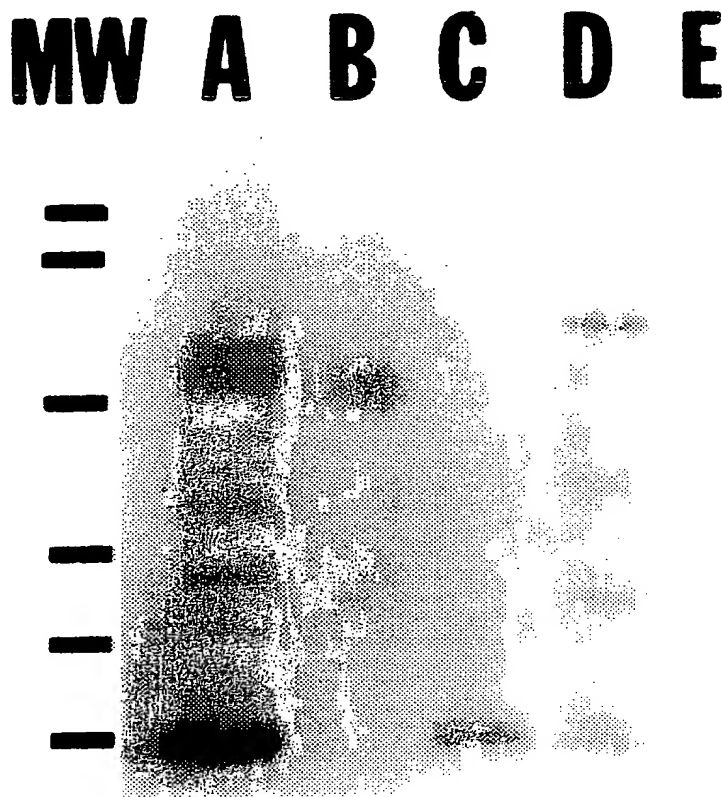
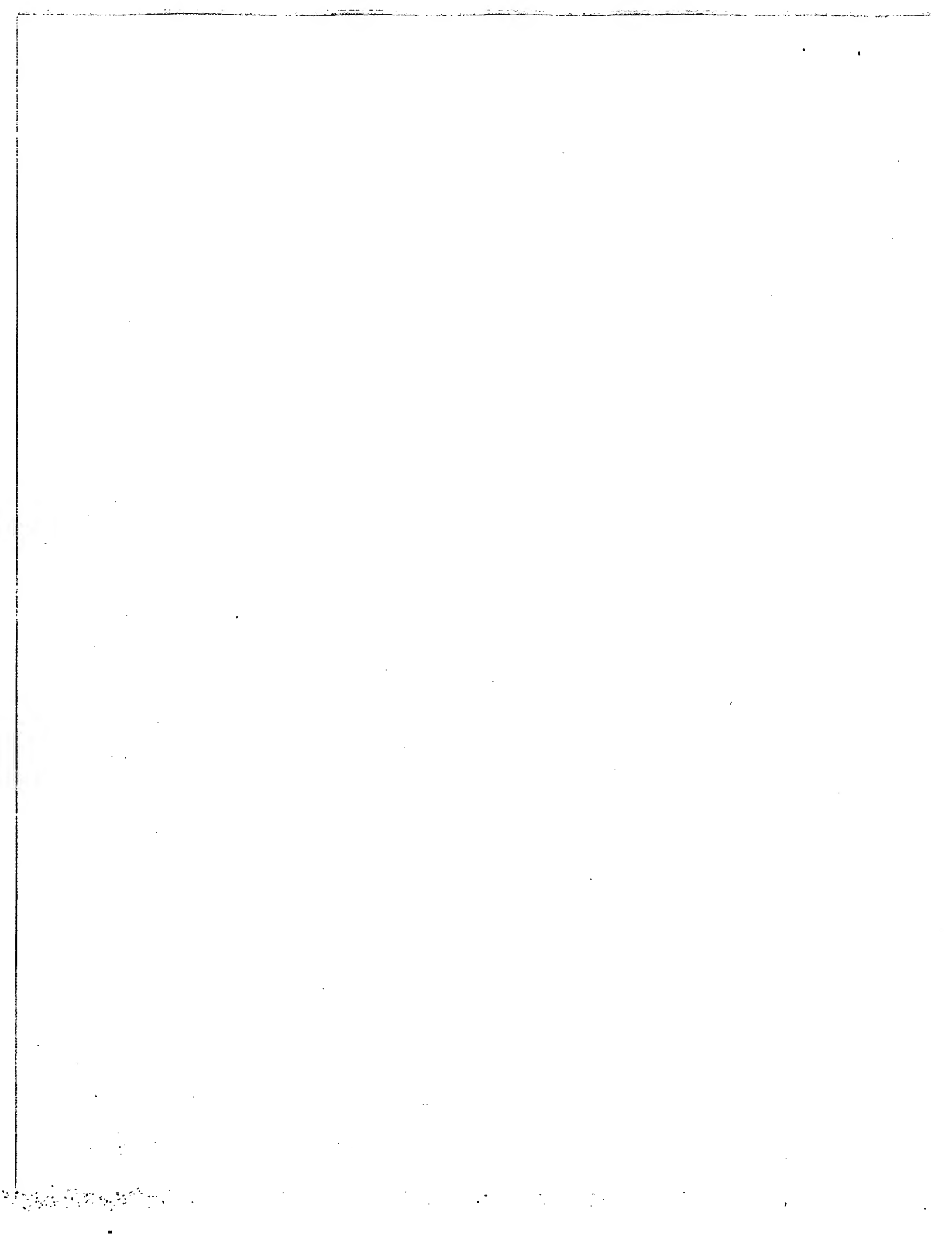
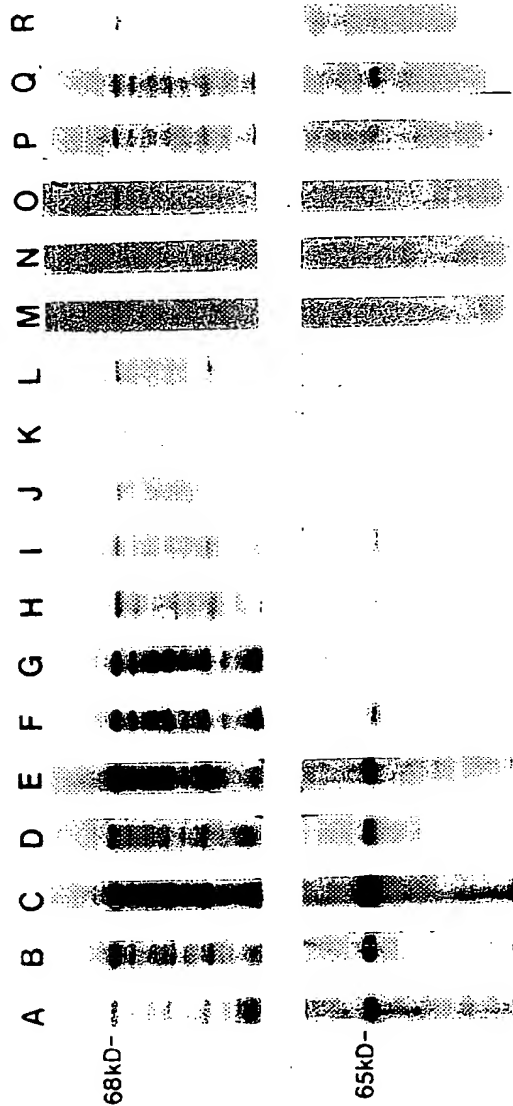


FIGURE 17

Serum IgE from a pool of peanut hypersensitive patients recognize recombinant *Ara h I*. Serum IgE from a pool of patients with reactivity to most peanut allergens was used to detect whole peanut extract (lane A), purified native *Ara h I* (lane B), recombinant *Ara h I* (lanes C and D), or *E. coli* extract (lane E). In preliminary experiments, we noted that full length clone P17 made small quantities of truncated recombinant protein (lane C). We found that by eliminating the first 93 bases of this clone we could produce large quantities of nearly full length *Ara h I* protein (lane D). The recombinant *Ara h I* (lane D; 68 kD) is larger than the native *Ara h I* (lane B; 65 kD) because the recombinant protein includes 37 amino acids of Beta galactosidase (See Methods for details of the expression system). Note that the serum IgE pool does not recognize any proteins in the *E. coli* extract (lane E) and therefore the other bands in lane D are truncated versions of *Ara h I*. MW, molecular weight standards expressed in kilodaltons.







Serum IgE from individual patients with peanut hypersensitivity recognize recombinant and native Ara h 1 protein in an immunoblot assay. (Upper panel) *E. coli* XL1-Blue cells carrying clone p172C were induced to express the recombinant Ara h 1 protein and lysates were prepared for immunoblot analysis. Each lane (A-R) represents a different patient with peanut hypersensitivity. (Lower panel) Lanes A-R, purified, native Ara h 1 protein was used in an immunoblot assay with serum IgE from the same individuals in the Upper Panel.

FIGURE 18



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## PEANUT ALLERGEN CLONING STRATEGY

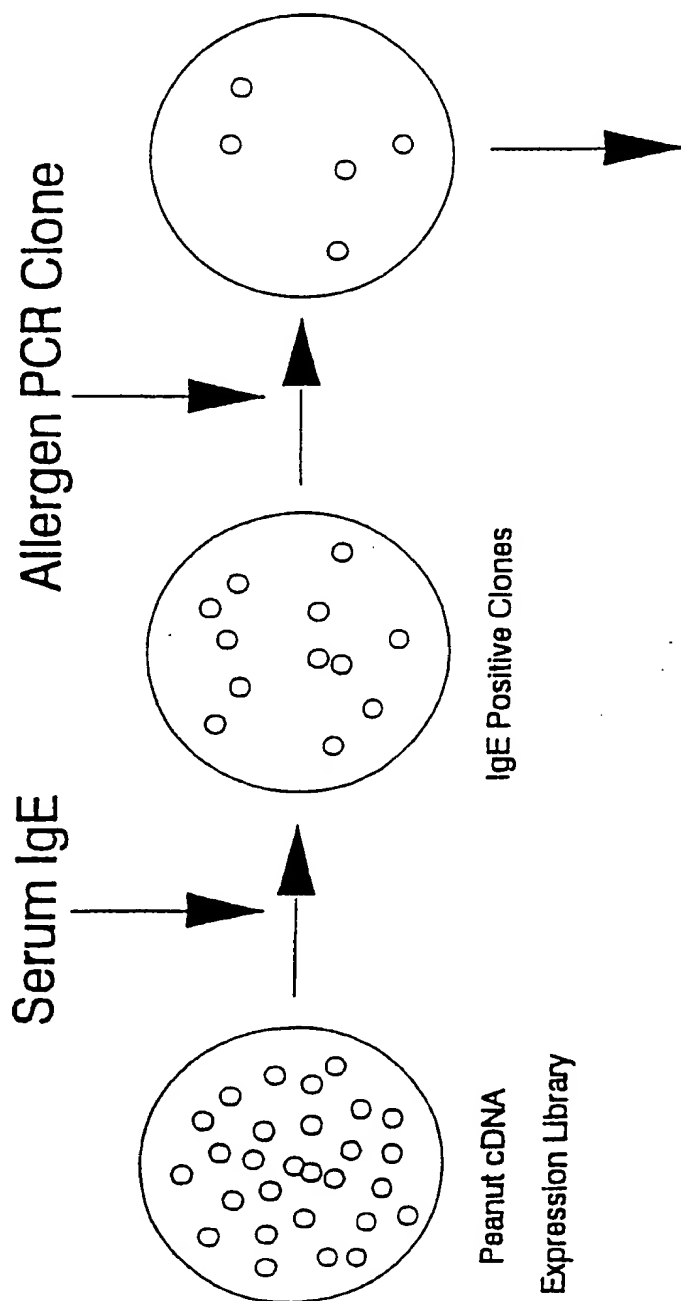
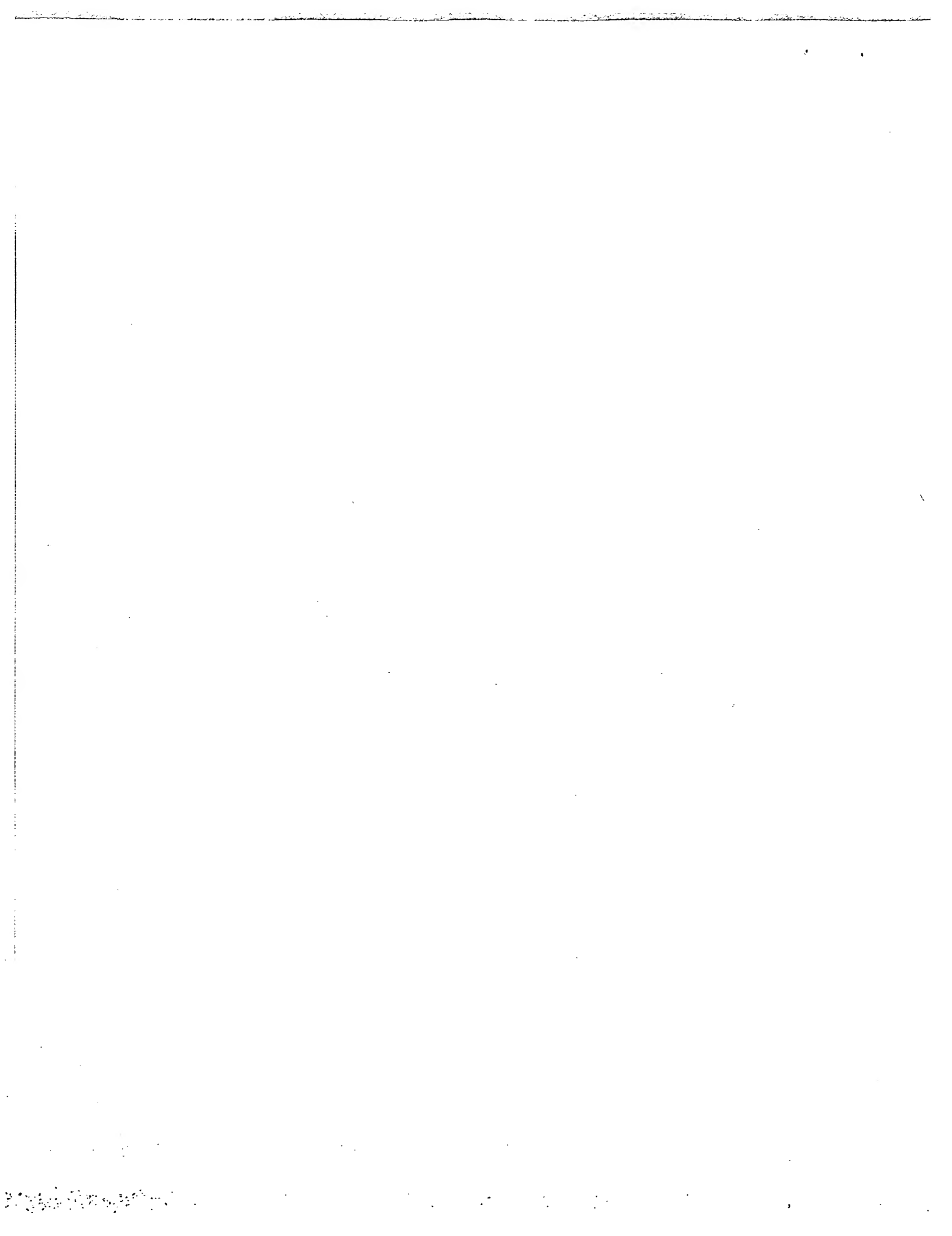


FIGURE 19

Allergen Specific Clones That  
Express IgE Recognized Protein



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5' EXO III DELETIONS			IgE Binding
Ara h I	NH <sub>2</sub> - [redacted] -COOH		+++
A	[redacted]		+++
B	[redacted]		+++
C	[redacted]		+++
D	[redacted]		++
E	[redacted]		++
F	[redacted]		++
G	[redacted]		+
H	[redacted]		-

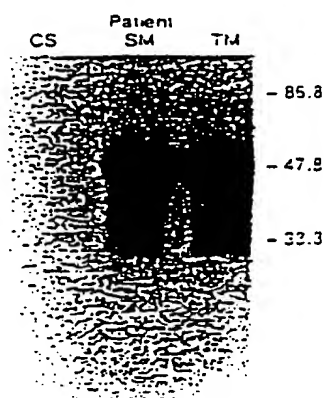
3' EXO III DELETIONS			IgE Binding
Ara h I	NH <sub>2</sub> - [redacted] -COOH		+++
A	[redacted]		+++
B	[redacted]		+++
C	[redacted]		+

FIGURE 20



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FIGURE 21







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Antigen.Index >= 1.7

Chou-Fasman Prediction  
June 20, 1995 09:33

PLOTSTRUCTURE of: Fp17arah1.Pep: 1 ck: 4271

TRANSLATE of: Fp17arah1.consensus check: 394 from: 3 to: 1967

NH2

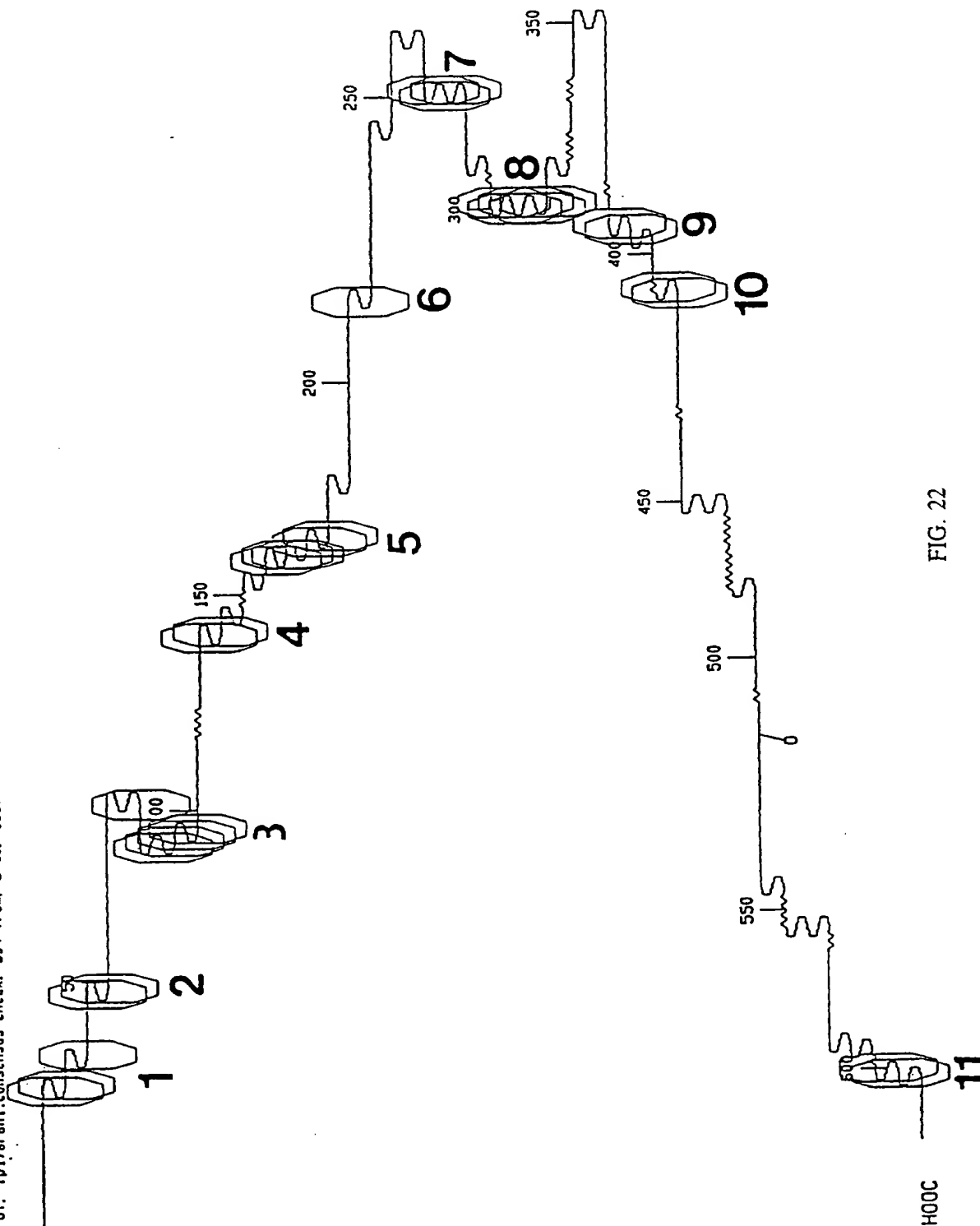
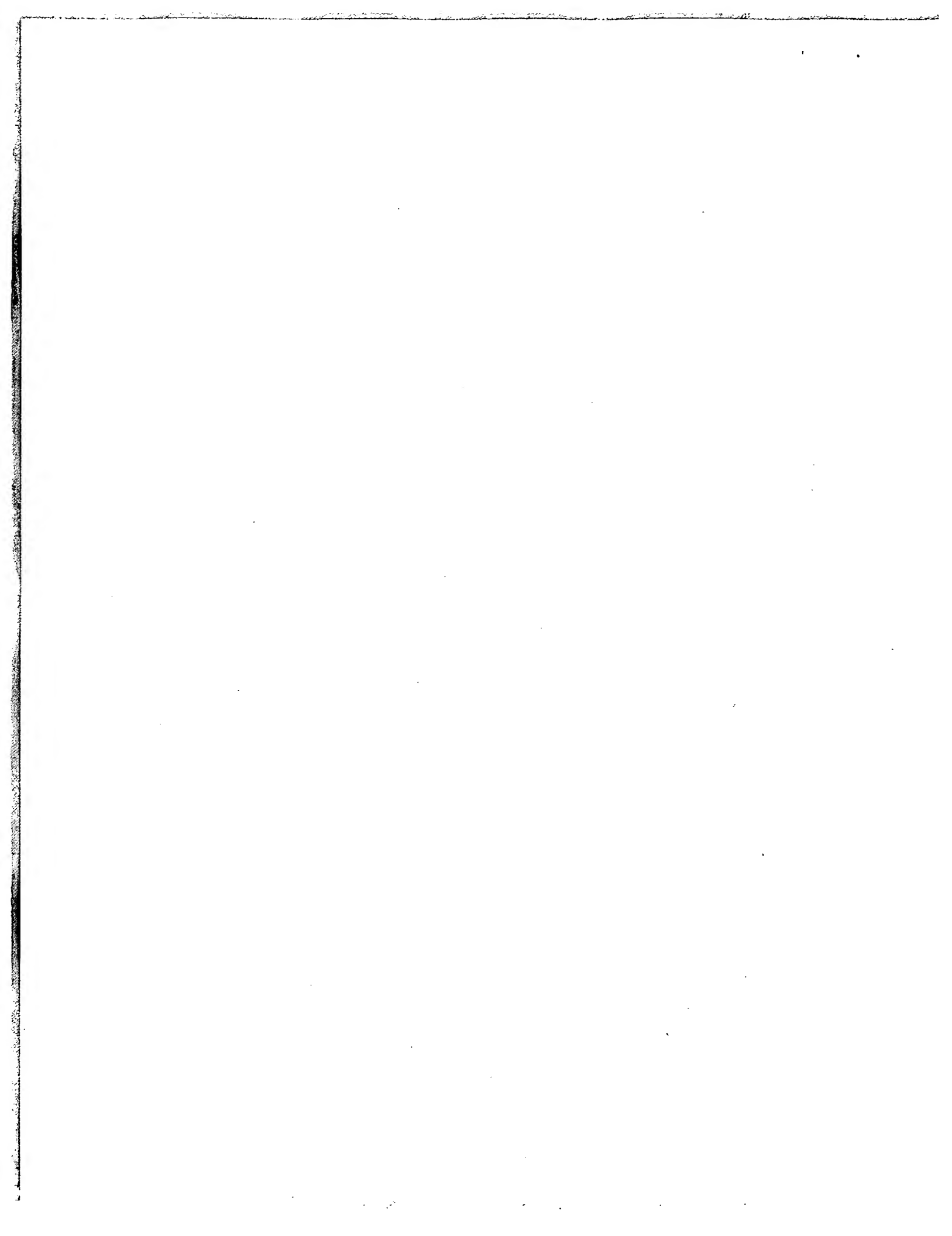


FIG. 22



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FIG. 23A

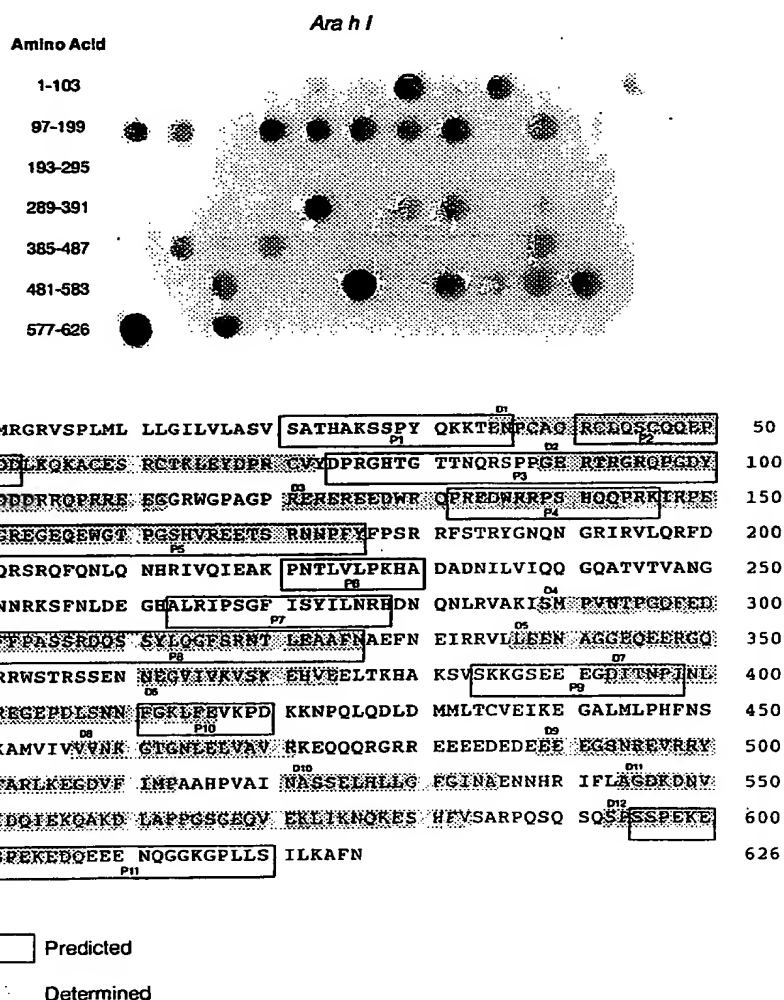
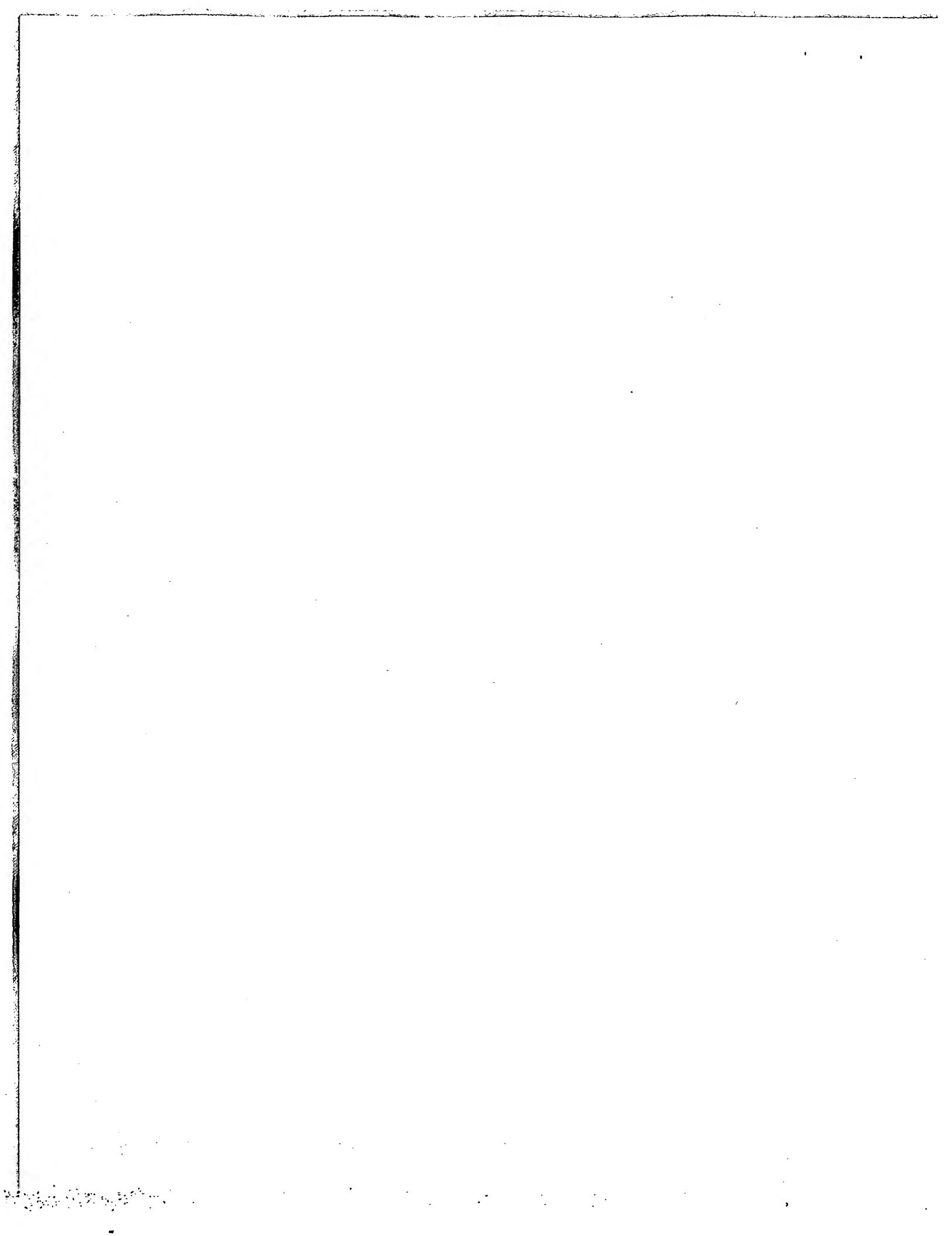


FIG. 23B



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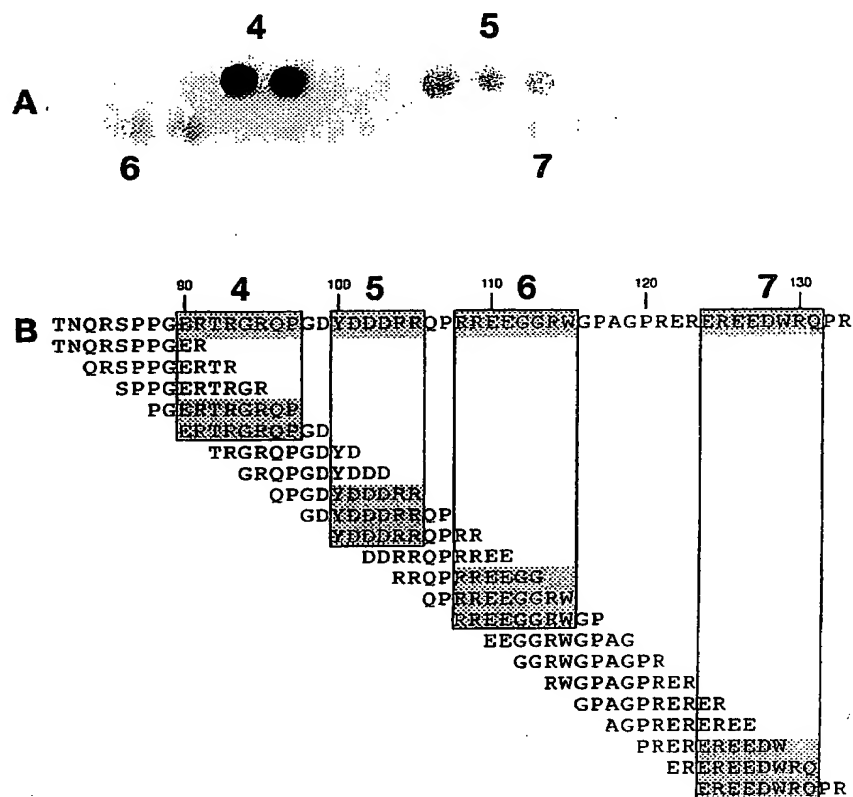
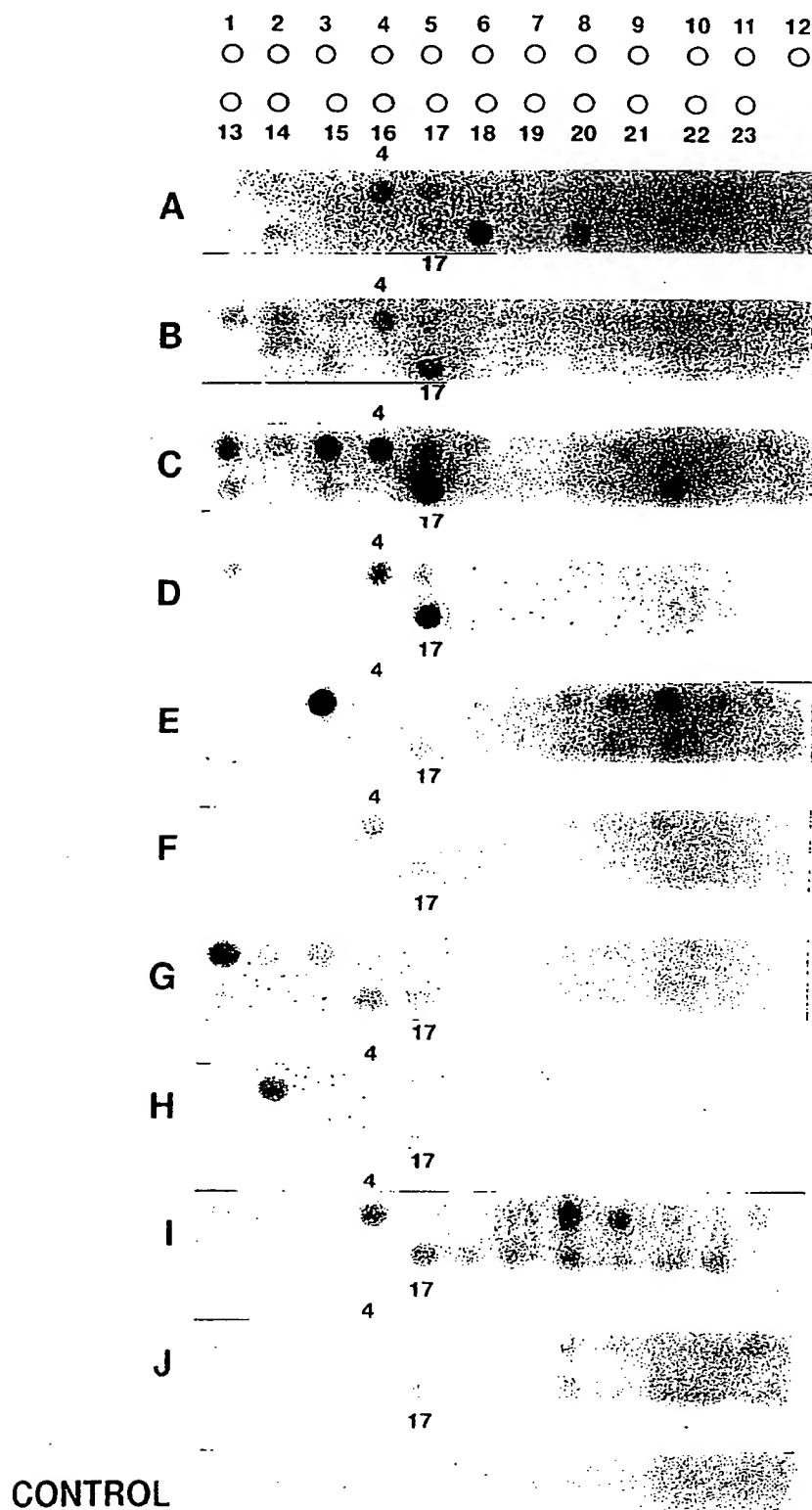


FIG. 24



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FIG. 25







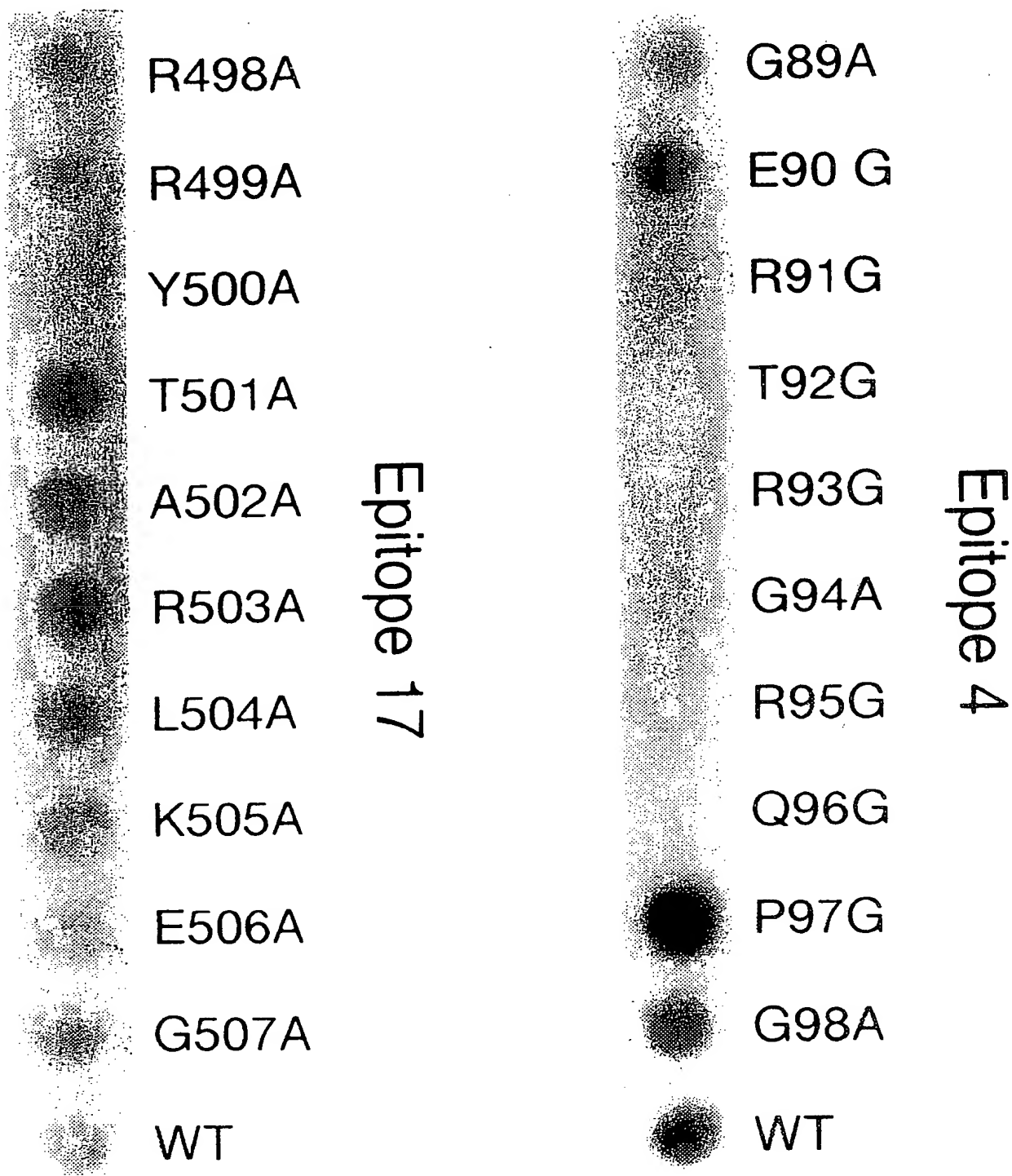


FIG. 26



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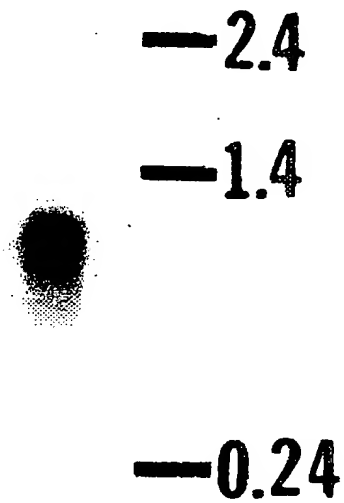
FIG. 27

## Ara h II Clone

ACG AGG CTC ACC ATA CTA GTA GCC CTC GCC CTT TTC CTC CTC GCT GCC 48  
 Thr Arg Leu Thr Ile Leu Val Ala Leu Ala Leu Phe Leu Leu Ala Ala  
 CAC GCA TCT GCG AGG CAG CAG TGG GAA CTC CAA GGA GAC AGA AGA TGC 96  
 His Ala Ser Ala Arg Gln Gln Trp Glu Leu Gln Gly Asp Arg Arg Cys  
 CAG AGC CAG CTC GAG AGG GCG AAC CTG AGG CCC TGC GAG CAA CAT CTC 144  
 Gln Ser Gln Leu Glu Arg Ala Asn Leu Arg Pro Cys Glu Gln His Leu  
 ATG CAG AAG ATC CAA CGT GAC GAG GAT TCA TAT GAA CGG GAC CCG TAC 192  
 Met Gln Lys Ile Gln Arg Asp Glu Asp Ser Tyr Glu Arg Asp Pro Tyr  
 AGC CCT AGT CAG GAT CCG TAC AGC CCT AGT CCA TAT GAT CGG AGA GGC 240  
 Ser Pro Ser Gln Asp Pro Tyr Ser Pro Ser Pro Tyr Asp Arg Arg Gly  
 GCT GGA TCC TCT CAG CAC CAA GAG AGG TGT TGC AAT GAG CTG AAC GAG 288  
 Ala Gly Ser Ser Gln His Gln Glu Arg Cys Cys Asn Glu Leu Asn Glu  
 TTT GAG AAC AAC CAA AGG TGC ATG TGC GAG GCA TTG CAA CAG ATC ATG 336  
 Phe Glu Asn Asn Gln Arg Cys Met Cys Glu Ala Leu Gln Gln Ile Met  
 GAG AAC CAG AGC GAT AGG TTG CAG GGG AGG CAA CAG GAG CAA CAG TTC 384  
 Glu Asn Gln Ser Asp Arg Leu Gln Gly Arg Gln Gln Glu Gln Gln Phe  
 AAG AGG GAG CTC AGG AAC TTG CCT CAA CAG TGC GGC CTT AGG GCA CCA 432  
 Lys Arg Glu Leu Arg Asn Leu Pro Gln Gln Cys Gly Leu Arg Ala Pro  
 CAG CGT TGC GAC TTG GAC GTC GAA AGT GGC GGC AGA GAC AGA TAC TAA 480  
 Gln Arg Cys Asp Leu Asp Val Glu Ser Gly Gly Arg Asp Arg Tyr  
 ACACCTATCTCAAAAAAAGAAAAGAAAAGAAAAGAAAATAGCTTATATATAAGCTATTATCTATGGTTAT  
 GTTTAGTTTTGGTAATAATAAAGATCATCACTATATGAATGTGTTGATCGTGTTAACTAAGGCAAGCTTA  
 GGTATATGAGCACCTTTAGAGTGCTTTTATGGCGTTGTCTATGTTTTGTTGCTGCAGAGTTGTAACCAT  
 CTTGAAATAATATAAAAAAGATCATGTTTTGTTAAAAA



FIG. 28





PLOTSTRUCTURE of: arah2p38.pep; 3 ck: 7865  
 TRANSLATE of: arah2p38.final check: 9822 from: 4 to: 480  
 Chou-Fasman Prediction  
 January 11, 1995 21:57  
 0 Antigen.Index >= 1.7

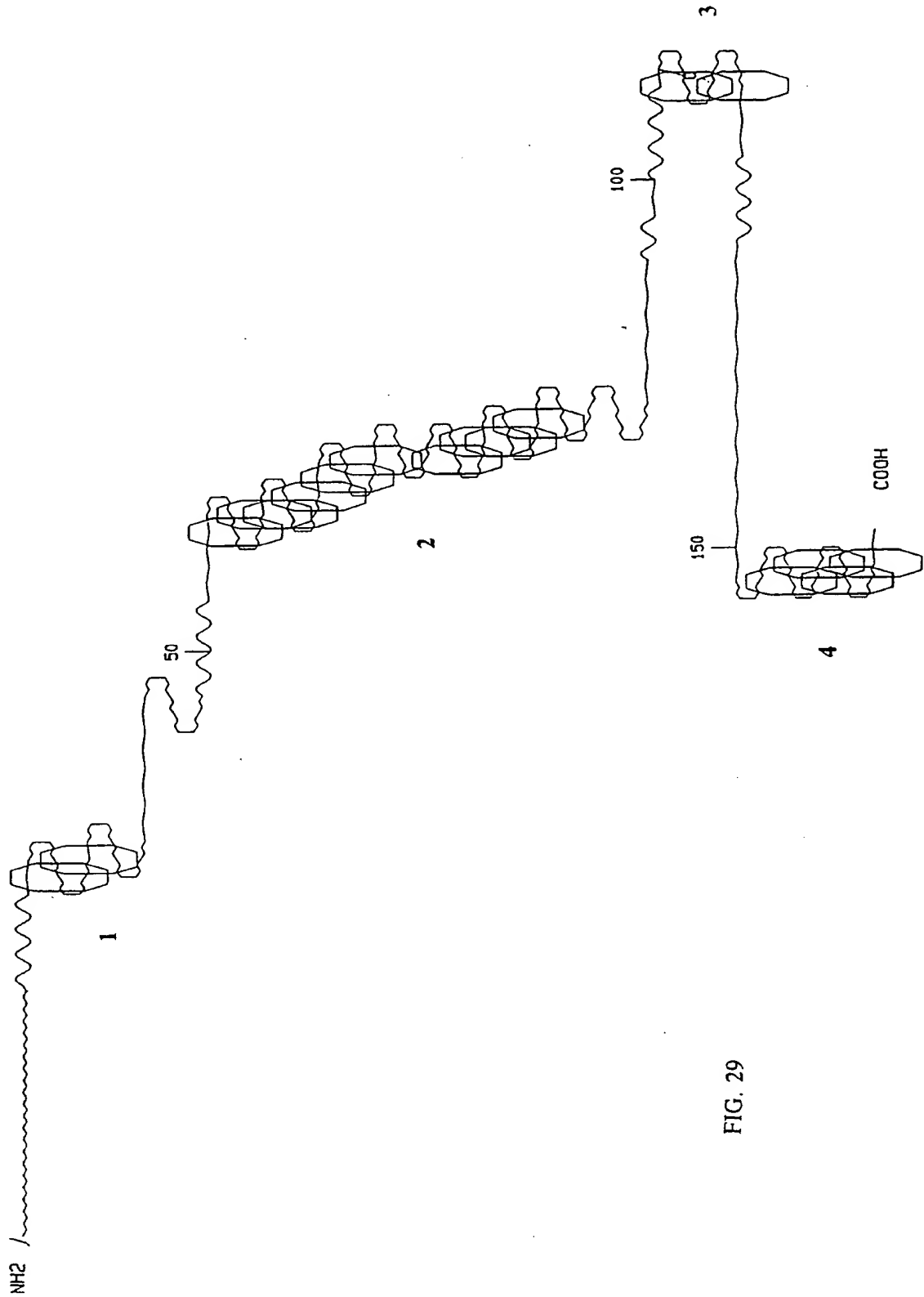
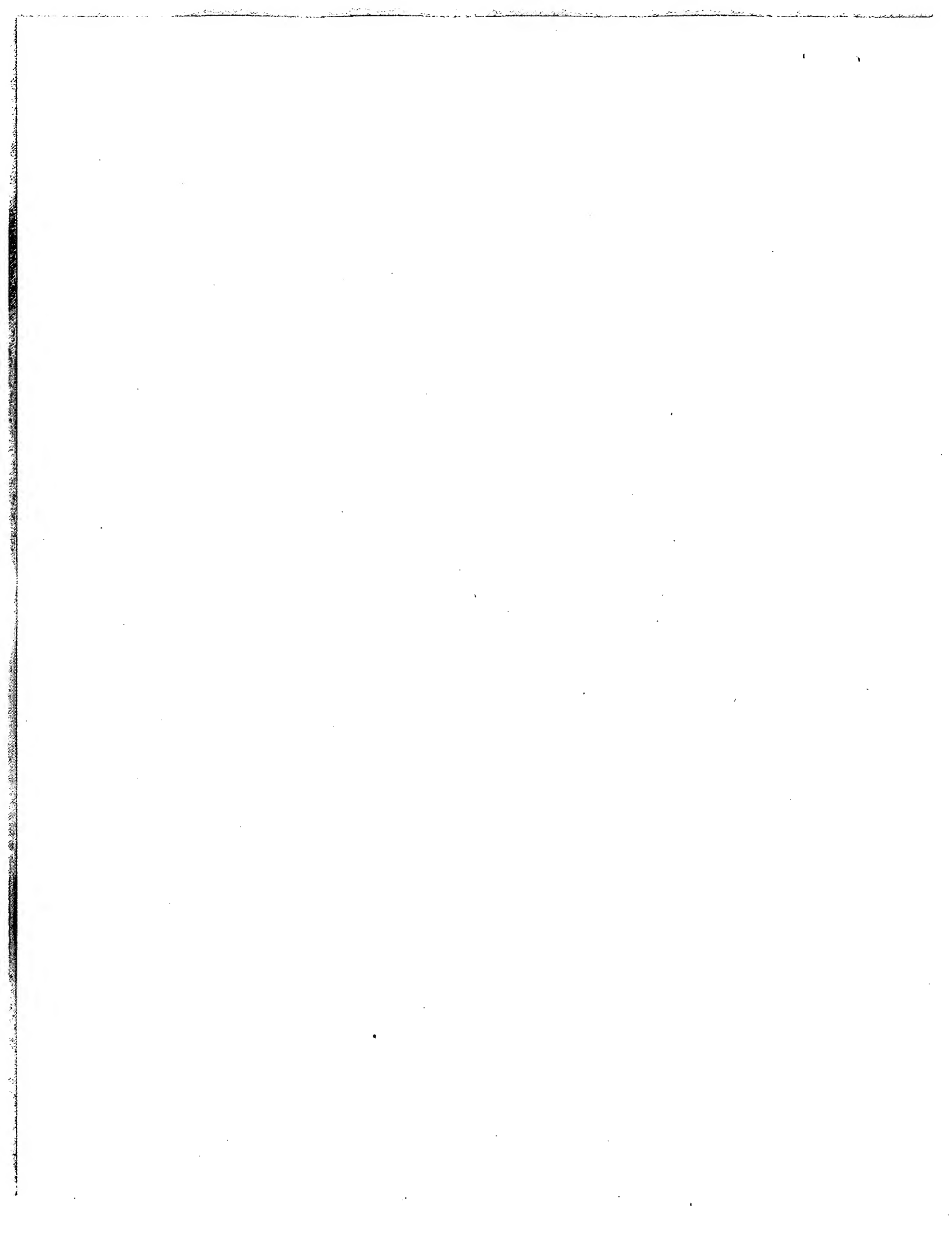


FIG. 29





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FIG. 30

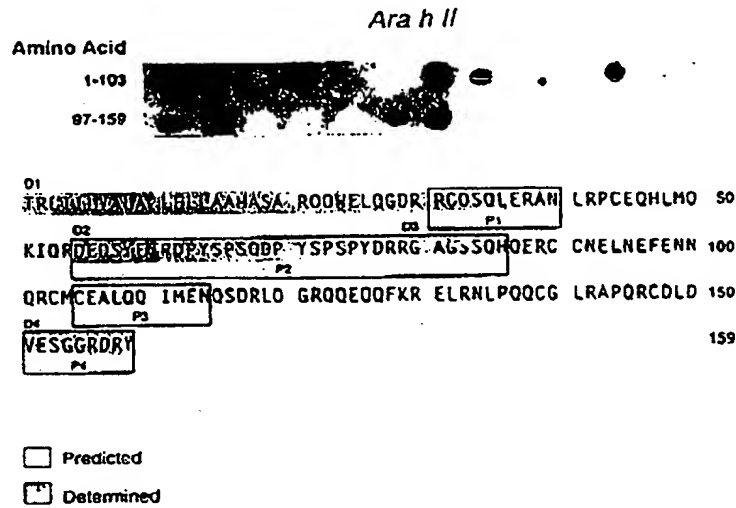
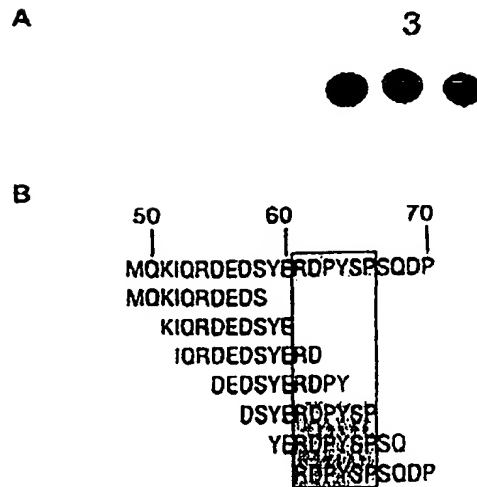


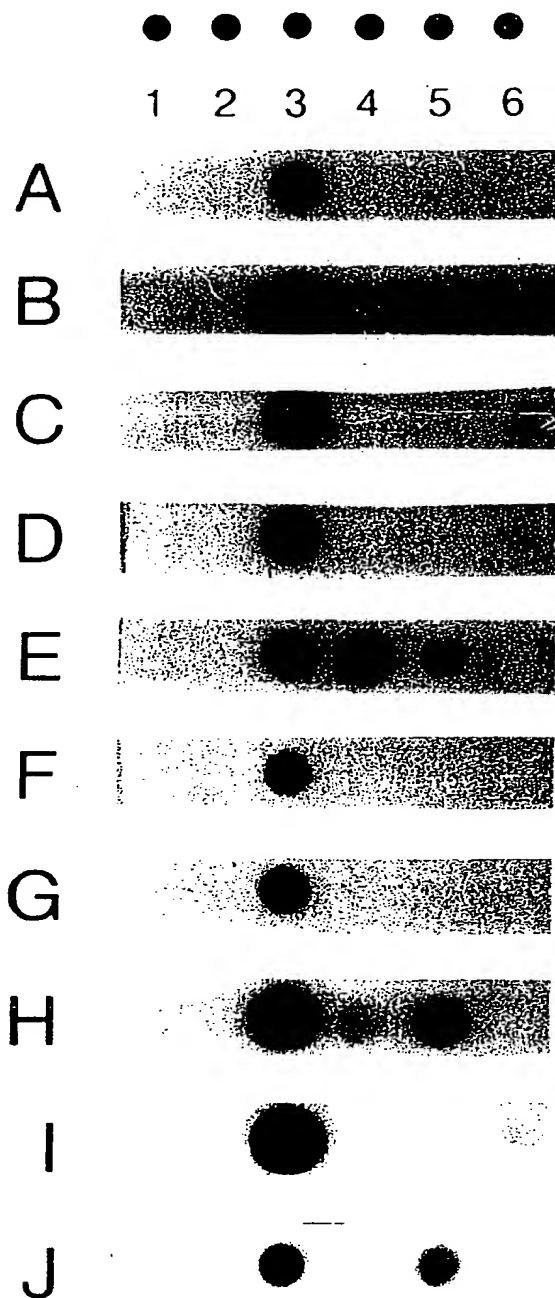
FIG. 31



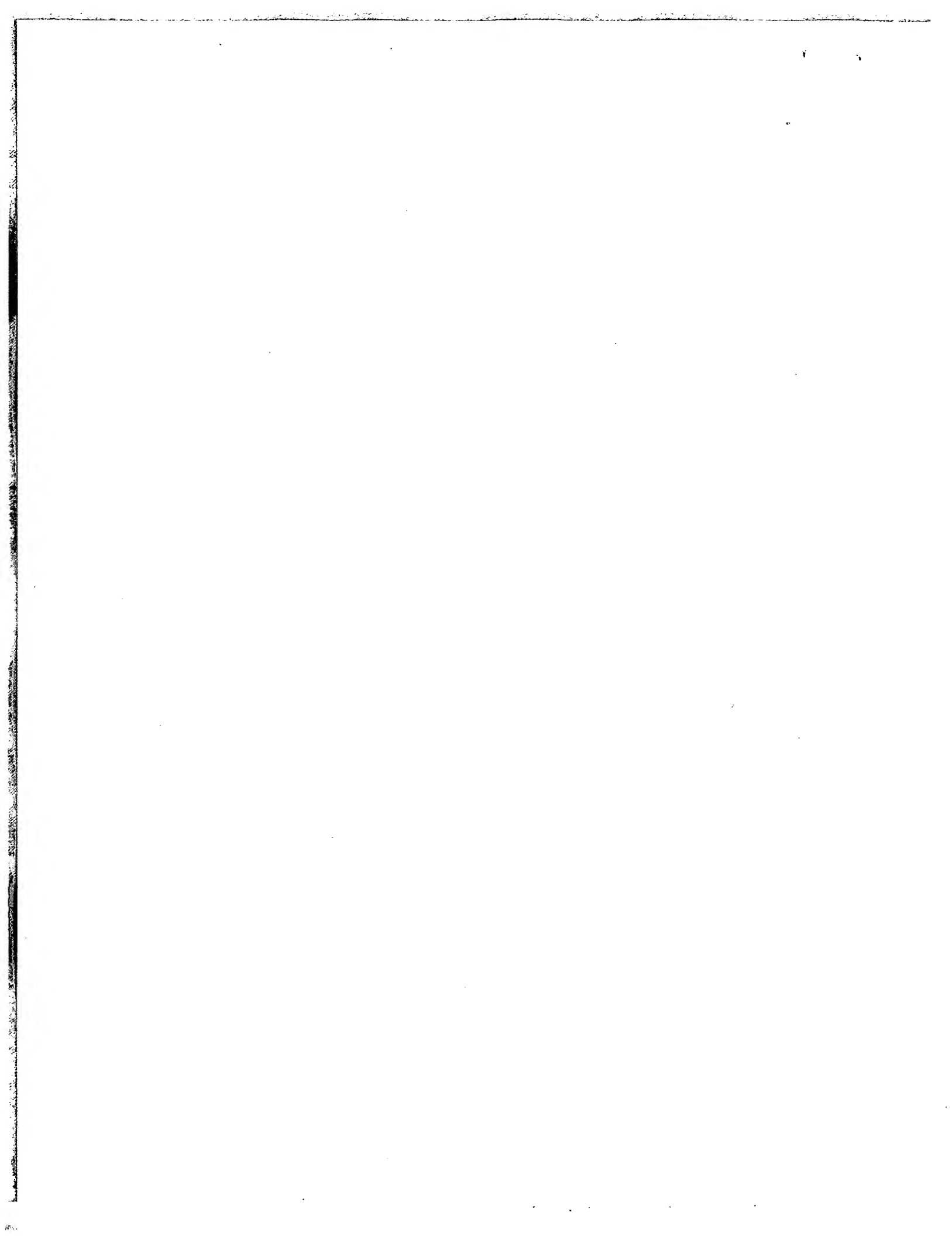


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FIG. 32



Control



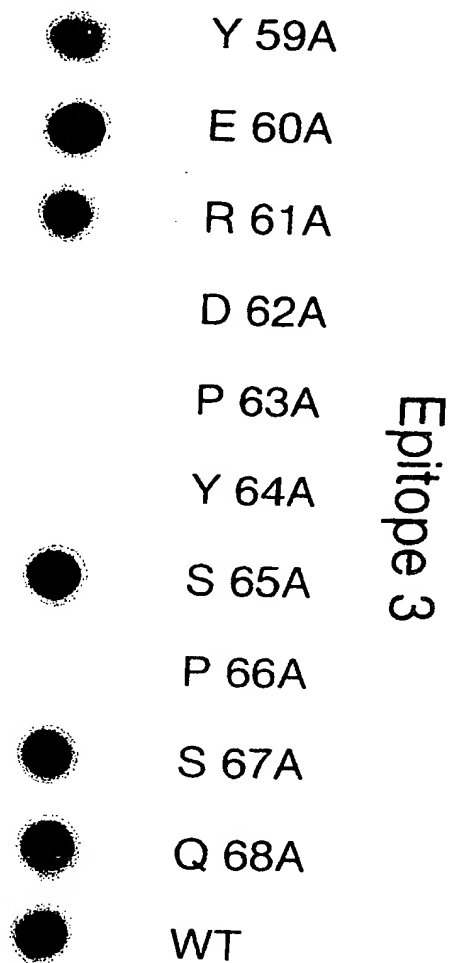


FIG. 33



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1 AATAATCATATATATTCATCAATCATCTATATAAGTAGTAGCAGGAGCA  
-----  
50 ATGAGAGGGGAGGGTTTCTCCACTGATGCTGTTGCTAGGGATCCTTGTCCTG  
.....  
M R G R V S P L M L L L G I L V L 17  
101 GCTTCAGTTTCTGCAACGCATGCCAAGTCATCACCTTACCAGAAGAAAAC  
.....G.....C.-----TT.CCG.....  
A S V S A T H A K S S P Y Q K K T 34  
151 AGAGAACCCCTGCGCCCAGAGGTGCCTCCAGAGTTGTCAACAGGAACCGG  
.....  
E N P C A Q R C L Q S C Q Q E P 50  
201 ATGACTTGAAGCAAAAGGCATGCGAGTCTCGCTGCACCAAGCTCGAGTAT  
.....  
D D L K Q K A C E S R C T K L E Y 67  
251 GATCCTCGTTGTGTCTATGATCCTCGAGGACACACTGGCACCACCAACCA  
.....G.....  
D P R C V Y D P R G H T G T T N Q 84  
301 ACGTTCCCCTCCAGGGGAGCGGACACGTGGCCGCCAACCCGGAGACTACG  
....CA.....  
R S P P G E R T R G R Q P G D Y 100  
351 ATGATGACCGCCGTCAACCCCGAAGAGAGGAAGGAGGCCGATGGGGACCA  
.....  
D D D R R Q P R R E E G G R W G P 117  
401 GCTGGACCGAGGGAGCGTGAAAGAGAAGAAGACTGGAGACAACCAAGAGA  
....A.....  
A G P R E R E R E E D W R Q P R E 134

FIGURE 34A





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451 AGATTGGAGGCGACCAAGTTCATCAGCAGCCACGGAAAATAAGGCCCGAAG  
.....  
D W R R P S H Q Q P R K I R P E 150

501 GAAGAGAAGGAGAACAAGAGTGGGGAACACCAGGTAGCCATGTGAGGGAA  
.....G.G.....  
G R E G E Q E W G T P G S H V R E 167

551 GAAACATCTCGGAACAACCCTTTCTACTTCCCGTCAAGGCGGTTTAGCAC  
.....A.....  
Peptide III E T S R N N P F Y F P S R R F S T 184

601 CCGCTACGGGAACCAAAACGGTAGGATCCGGGTCCTGCAGAGGTTTGACC  
.....C.....  
R Y G N Q N G R I R V L Q R F D 200

651 AAAGGTCAAGGCAGTTTCAGAATCTCCAGAATCACCGTATTGTGCAGATC  
.....A.....  
Q R S R Q F Q N L Q N H R I V Q I 217

701 GAGGCCAAACCTAACACTCTTGTTCTTCCCAAGCACGCTGATGCTGATAA  
.....G.....  
E A K P N T L V L P K H A D A D N 234

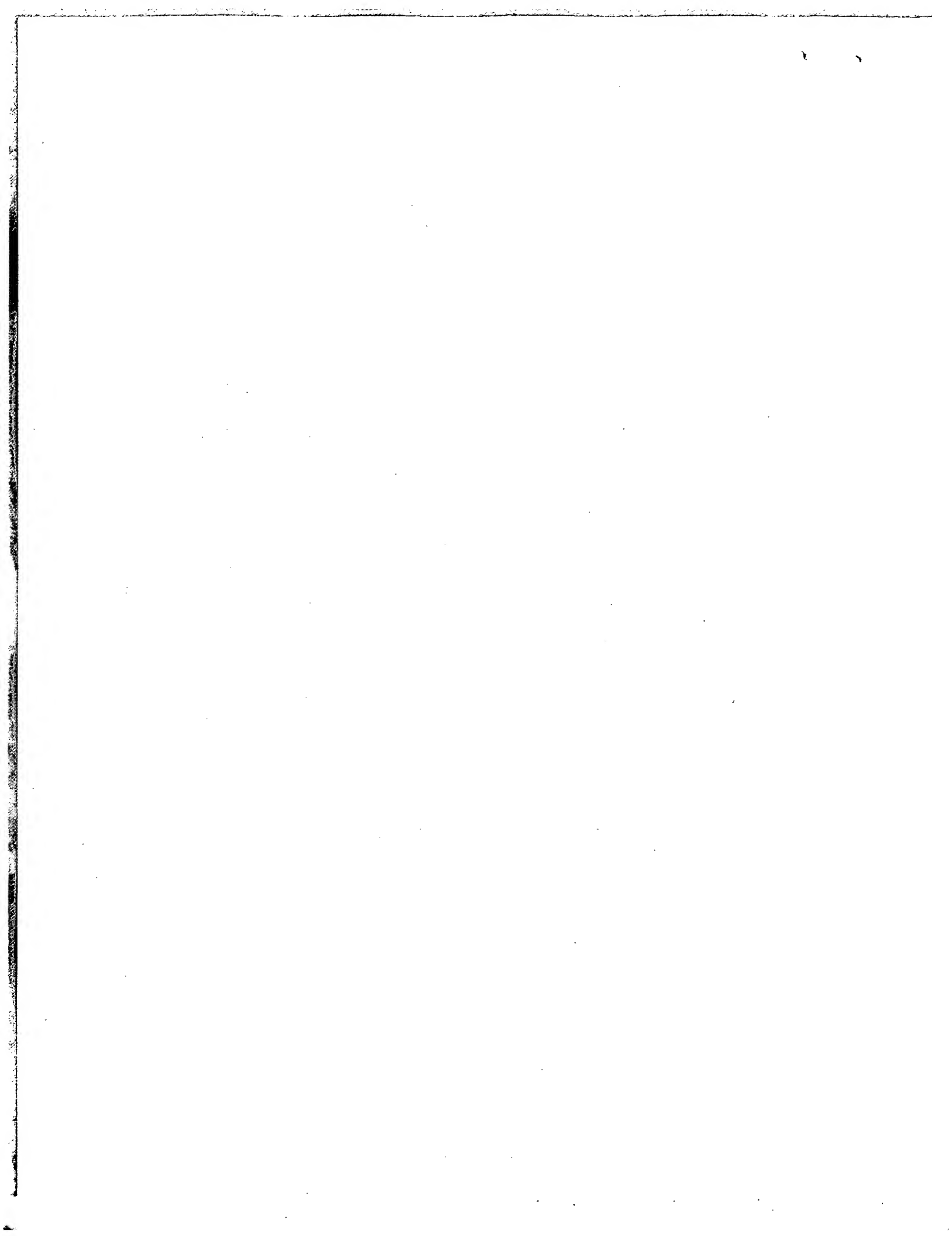
751 CATCCTTGTTATCCAGCAAGGGCAAGCCACCGTGACCGTAGCAAATGGCA  
.....A.....  
I L V I Q Q G Q A T V T V A N G 250

801 ATAACAGAAAGAGCTTTAATCTTGACGAGGGCCATGCACTCAGAATCCCA  
.....  
N N R K S F N L D E G H A L R I P 267

851 TCCGGTTTCATTTCTACATCTTGAACCGCCATGACAACCAGAACCTCAG  
.....T..A.....  
S G F I S Y I L N R H D N Q N L R 284

901 AGTAGCTAAAATCTCCATGCCCCGTTAACACACCCGGCCAGTTTGAGGATT  
.....G.....  
A A K I S M P V N T P G Q F E D 300

FIGURE 34B



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951 TCTTCCCGGCGAGCAGCCGAGACCAATCATCCTACTTGCAGGGCTTCAGC  
.....A.....  
F F P A S S R D Q S S Y L Q G F S 317

1001 AGGAATACGTTGGAGGCCCGCCTTCAATGCGGAATTCAATGAGATACGGAG  
.....T.....  
R N T L E A A F N A E F N E I R R 334

1051 GGTGCTGTTAGAAGAGAATGCAGGAGGTGAGCAAGAGGAGAGAGGGCAGA  
.....A.....  
V L L E E N A G G E Q E E R G Q 350

1101 GGCGATGGAGTACTCGGAGTAGTGAGAACAATGAAGGAGTGATAGTCAAA  
.....C.....--T.....  
R R W S T R S S E N N E G V I V K 367

1151 GTGTCAAAGGAGCACGTTGAAGAACTTACTAAGCACGCTAAATCCGTCTC  
.....C.....  
V S K E H V E E L T K H A K S V S 384

1201 AAAGAAAGGCTCCGAAGAAGAGGGAGATATCACCAACCCAATCAACTTGA  
.....A---.....  
Peptide II K K G S E E E G D I T N P I N L 400

1251 GAGAAGGCGAGCCCGATCTTTCTAACAACCTTTGGGAAGTTATTTGAGGTG  
.....T.....G.....  
R E G E P D L S N N F G K L F E V 417

1301 AAGCCAGACAAGAAGAACCCCCAGCTTCAGGACCTGGACATGATGCTCAC  
.....  
K P D K K N P Q L Q D L D M M L T 434

1351 CTGTGTAGAGATCAAAGAAGGAGCTTTGATGCTCCCACACTTCAACTCAA  
.....  
C V E I K E G A L M L P H F N S 450

FIGURE 34C



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1401 AGGCCATGGTTATCGTCGTCGTCAACAAAGGAACTGGAAACCTTGAAGTC  
.....C.....  
K A M V I V V V N K G T G N L E L 467

1451 GTGGCTGTAAGAAAAGAGCAACAACAGAGGGGACGGCGGGAA-----  
..A.....CAAGAGTC  
V A V R K E Q Q Q R G R R E - - - 481

1493 -GAAGAGGAGGACGAAGACGAAGAAGAGGAGGGAAGTAACAGAGAGGTGC  
G.....A.....G.....T.....  
E E E D E D E E E E G S N R E V 497

1542 GTAGGTACACAGCGAGGTTGAAGGAAGGCGATGTGTTCATCATGCCAGCA  
.....  
R R Y T A R L K E G D V F I M P A 514

1592 GCTCATCCAGTAGCCATCAACGCTTCCTCCGAACCTCCATCTGCTTGGCTT  
.....  
A H P V A I N A S S E L H L L G F 531

1642 CGGTATCAACGCTGAAAACAACCACAGAATCTTCCTTGCAGGTGATAAGG  
.....  
Peptide I G I N A E N N H R I F L A G D K 547

1692 ACAATGTGATAGACCAGATAGAGAAGCAAGCGAAGGATTTAGCATTCCTT  
.....  
D N V I D Q I E K Q A K D L A F P 564

1742 GGGTCGGGTGAACAAGTTGAGAAGCTCATCAAAAACCAGAAGGAATCTCA  
..T.....G...G.....  
G S G E Q V E K L I K N Q K E S H 581

1792 CTTTGTGAGTGCTCGTCCTCAATCTCAATCTCAATCTCCGTCGTCTCCTG  
.....CG.....  
F V S A R P Q S Q S Q S P S S P 597

1842 AGAAAGAGTCTCCTGAGAAAGAGGATCAAGAGGAGGAAAACCAAGGAGGG  
-----A.....  
E K E S P E K E D Q E E E N Q G G 614

FIGURE 34D



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```

1892  AAGGGTCCACTCCTTTCAATTTGAAGGCTTTTAACTGAGAATGGAGGCA
      .....A.
      K G P L L S I L K A F N
      626

1942  ACTTGTTATGATCGATAATAAGATCACGCTTTTGTTACTCTACTATCCAA
      .....C.....A.....
      .....

1992  AAACCTTATCAATAATAAAACGTTTGTGCGTTGTTCTCCAAAAAAA
      .....

```

Nucleotide sequence of an *Ara h 1* cDNA clone. The nucleotide sequence of clone 41B is shown on the first line. The second line depicts clone P17 DNA sequence with dots (.) representing nucleotides that are the same, dashes (-) nucleotides that are missing, and A, C, G, or T nucleotides that differ between the two DNA sequences. The protein synthesis start (ATG) and stop (TGA) sites are underlined along with a consensus polyadenylation signal (AATAAA). Bold amino acid residues are those areas which correspond to the determined amino acid sequence of peptides I, II, and III of *Ara h 1* (Table 14). The numbers on the left of the figure indicate the nucleotide sequence, and those on the right correspond to the deduced amino acid sequence. These sequence data are available from GenBank under accession number L34402.

FIGURE 34E





## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/15222**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : A61K 39/00, 39/35, 39/395; C07K 14/415, 16/00; G01N 33/53, 33/543

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 424/276.1, 810; 435/7.1, 7.92, 7.94; 436/548; 530/370, 387.1, 403, 868

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Medline, Biosis, Embase, Intelligenetics

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	J. Allergy Clin. Immunol., Volume 90, Number 6, issued December 1992, Burks et al., "Identification and characterization of a second major peanut allergen, <i>Ara h</i> II, with use of the sera of patients with atopic dermatitis and positive peanut challenge", pages 962-969, see entire document.	1-32
Y	J. Allergy Clin. Immunol., Volume 86, Number 1, issued July 1990, Keating et al., "Immunoassay of peanut allergens in food-processing materials and finished foods", pages 41-44, see entire document.	1-32

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A document defining the general state of the art which is not considered to be of particular relevance	*X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E earlier document published on or after the international filing date	*Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G document member of the same patent family
*O document referring to an oral disclosure, use, exhibition or other means	
*P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

18 JANUARY 1997

Date of mailing of the international search report

06 FEB 1997

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

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Authorized officer

LAURIE SCHEINER

Telephone No. (703) 308-0196

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US96/15222

**Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)**

The abstract is too long, it exceeds 200 words (PCT Rule 8.1(b)).

**NEW ABSTRACT**

Crude Florunner extracts were fractionated by anion-exchange chromatography using a step gradient. A protein peak which eluted at 10% NaCl and demonstrated intense IgE-binding was further analyzed by two-dimensional SDS-PAGE/immunoblot analysis. The majority of this fraction is a protein which has a molecular weight of 17 kD and a pI of 5.2. Sequencing data from the N-terminus revealed the following initial 9 amino acids: (\*)-Q-Q-(\*)-E-L-Q-D-L. Based on IgE-binding activity and no known amino acid sequence identity to other allergens, this allergen is designated Ara h II. Ara h II may be used to detect and quantify peanut allergens in foodstuffs. Serum IgE from patients with documented peanut hypersensitivity reactions and a peanut cDNA expression library were used to identify clones that encode peanut allergens. One of the major peanut allergens, Ara h I, was selected from these clones using Ara h I specific oligo-nucleotides and polymerase chain reaction technology.

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/15222

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Biochimica et Biophysica Acta, Volume 882, issued 1986, Barnett et al., "Partial characterization of an allergenic glycoprotein from peanut ( <i>Arachis hypogaea</i> L.)", pages 97-105, see entire document.	1-32
Y	J. Allergy Clin. Immunol., Volume 88, Number 2, issued August 1991, Burks et al., "Identification of a major peanut allergen, <i>Ara h</i> I, in patients with atopic dermatitis and positive peanut challenges", pages 172-179, see entire document.	1-32

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/15222

## A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

424/276.1, 810; 435/7.1, 7.92, 7.94; 436/548; 530/370, 387.1, 403, 868